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INFILTRATION OF WATER INTO THE SOIL

Compiled by
J. M. Davidson

Soil Conservation
Bibliography No. 3
October 1940

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FOREWORD

In this bibliography an attempt has been made to cover the field of published material on the subject of infiltration. Infiltration is considered as the absorption of liquid water by a zone of aeration. It includes the formation and upbuilding of surcharged films around soil-grains through wetting by rainfall, melting snow, or temporary sheet water, and the movement into the soil of mobile water by film flow, trickling or percolation toward the water table.

The annotations were prepared with the intention of permitting the technician interested in infiltration to determine whether the published contribution contains information applicable to his interests. These annotations are not complete abstracts or conclusions but they consist of information to guide the student in his investigations of infiltration. The references are arranged alphabetically according to author. They refer to published material relating to the rate of entry of water into the soil, to infiltration capacity of surface soil, or to soil, water, or air characteristics which directly affect infiltration or its rate. There are a few exceptions included, such as articles in which the author speaks directly of "infiltration" (of water into the soil) which do not give either a measured quantity or rate of entry.

Those characteristics which directly affect the rate of infiltration are such factors as soil structure, soil texture, non-capillary pore space, temperature of the soil or viscosity of the water, the action of soil amendments or electrolytes in water upon the pore space and the shrinking and swelling of colloidal material. This phase of the bibliography is not exhaustive but contains many references pertinent to infiltration or its rate.

The bibliography has been selected from general sources of reference material such as the Experiment Station Record, Agricultural Index, Chemical Abstracts, Science Abstracts, and Industrial Arts Index, and from those publications referred to by the authors in their centributions. References to foreign publications have been included when found, but it is realized that the field of foreign literature has not been thoroughly searched.

The date of the earliest reference included is the year 1884. Most of these references have been published within the last two decades with the majority appearing since the year 1934. These publications, with a few exceptions, are available in the Library of the United States Department of Agriculture, as indicated by the library call numbers following the entry. The numerical symbols preceding the entry correspond to those used in the index.

May 1, 1940

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SOURCES CONSULTED

Card catalogues of the following libraries:

U.S. Department of Agriculture
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Indexes:

Agricultural Index, April 1940
Chemical Abstracts, 1907-1939
Imperial Bureau of Soil Science. Soils and Fertilizers, v.1-3, no.2, 1938-1940
Industrial Arts Index, 1913-1939
Science Abstracts, part A, 1898-1937
U.S. Office of Experiment Stations. General Index to Experiment Station Record v.1-80, 1889-1939
U.S. Soil Conservation Service. Library. Soil Conservation Literature: Selected Current References, v.1-3, January/February 1937-March/April 1940

INFILTRATION OF WATER INTO THE SOIL
A list of References
Relative to the Physical Aspects of the Principal Factors Affecting the Rate and Its Measurement

Compiled by J. M. Davidson
Soil Conservation Service

1. American geophysical union. Transactions of the ... sixteenth annual meeting April 25 and 26, 1935, Washington, D.C. 2 parts, illus. Washington, D.C., Published by the National research council of the National academy of sciences, August 1935. 330.9 Am3 16th 1935.

   Part II. Reports and papers, Section of hydrology, pp.367-530.

   Of interest is the Report of the committee on rainfall and run-off, 1934-35, L.K.Sherman, chairman.

   Appendix A. The experimental study of run-off, pp.405-411. Infiltration comes under consideration from the use of a rainfall-analyzer since it separates the rainfall into its two main components, surface run-off and infiltration. The article consists of a discussion.

   Appendix B. Experimental plots for run-off in operation or recently established, pp.411-416.

   Experimental plots provided with artificial rainfall to determine the relation between precipitation, infiltration, surface storage, and run-off for particular soil and surface-slopes were established at St.Louis, Missouri, and Dallas, Texas, and reported by W.W.Horner.

   Plots one-foot square and others six-foot square are subjected to artificial rainfall of known quantity applied manually by means of sprinklers. Tests were started in 1930. Rates of application and run-off were determined. These experiments were made by D.A.Lane for Los Angeles City Water Department and by F.B. Laverty for Los Angeles County Flood Control District. Typical graphs are presented showing rainfall versus run-off in inches per hour for plots of 100 square feet located near Los Angeles. Absorption curves in inches per hour for each plot are prepared from tests made by L.W.Armstrong of Los Angeles Bureau of Engineering.

   Appendix C. The infiltration theory of surface-run-off, pp. 416-419. Formulas are expressed and discussed for various factors that directly affect run-off characteristics. No experimental data are presented. The article is based on theory only.

Also of interest is the Report of the committee on absorption and transpiration, 1934-35, Charles H. Lee, chairman, pp. 392-404.

The investigations of absorption, run-off, and other factors, which may include infiltration by means of lysimeters, small plots and small watersheds are summarized for the San Dimas Experimental Forest, North Fork and Bass Lake, Sierra Forest, at Berkeley, California. The lysimeters at San Dimas include 48 small weighing types (unit weight 350 pounds) sensitive to 7 grams and 30 large weighing types (unit weight 1800 pounds) sensitive to 8 ounces.

The definition given for "infiltration is the absorption of liquid water by a zone of aeration. It includes the formation and upbuilding of surcharged films around soil-grains through wetting by fog-drip, rainfall, melting snow, or temporary sheet-water, and the downward movement of mobile water into the soil by film-flow, trickling or percolation after the demand for pellicular water has been satisfied." It is sometimes erroneously termed "rainfall-penetration". The term is frequently used in a sense more or less synonymous with absorption, but has been limited to liquid water entering the zone of aeration. Loss of water from streams into unsaturated material is included in infiltration.

2. American geophysical union. Transactions of the ... seventeenth annual meeting April 30, May 1, 2, 1936, Washington, D.C.; West Coast meeting January 31 and February 1, 1936, Pasadena, California. 2 parts, illus. Washington, D.C., Published by the National research council of the National academy of sciences, July 1936.
330.9 Am3 17th, 1936.

Part II. Reports and papers, Section of hydrology and Western interstate snow-survey conference, pp. 263-562.

Of interest is the Report of the committee on physics of soil moisture, 1935-36 (Physical properties of soils as affected by the degree of cation saturation) F. J. Veihmeyer, chairman, pp. 318-326.

Permeability studies showed that the monovalent ions produced membranes having the lowest permeability. Hydrogen-saturated systems were always more permeable than calcium-saturated. C. Rotkin found that high heads of water cause small increase in both penetration and percolation in flocculated soils. In deflocculated soils the reverse was true and the penetration of water into the soils was retarded by sodium and potassium compounds and by clay and silt.

T. E. Buehrer and H. V. Smith found from studies on percolation rates for various soils the principal factor in the penetration and percolation of water to be the pH of the percolating solution. Percolation rates were greatly decreased by the addition of sodium carbonate.

R. E. Stephenson has noted improvement in penetration of irrigation water on black alkali land as calcium was gradually substituted for sodium in the exchange-complex.

R. P. Thomas finds that the addition of alkali-bases, particularly sodium, decreased the rate of percolation and the alkali-earths increased it.

3. American geophysical union. Transactions of the ... nineteenth annual meeting April 27 to 30, 1938, Washington, D.C.; Regional meetings December 28, 29, 1937, Spokane, Washington; January 7, 8, 1938, Davis, California; June 21, 1937, Denver, Colorado (Addendum). 2 parts, illus. Washington, D.C., Published by the National research council of the National academy of sciences, August 1938. 330.9 Am3 19th, 1938.

Part I. Reports and papers, Washington, D.C., General assembly and Sections of geodesy, seismology, meteorology, terrestrial magnetism and electricity, oceanography, volcanology, and hydrology, pp.1-584.

Of interest is the Report of the committee on physics of soil moisture, 1937-38 (Effect of organic matter on the infiltration of water into soils) F.J. Veihmeyer, chairman, pp.326-342.

The replies of the committee members are given in whole or in part to the seven questions submitted by the chairman for their views on the above subject. Five of these questions were directly concerned with the rate of entry of water into soils and the other two were concerning factors relevant to the same. Although no tabular data were submitted, the consensus of opinion on some of the questions was:

Incorporated organic matter increased the rate of entry of water into soils.

The roughening of the surface of the soil by plowing may decrease the rate of overland flow and the organic matter itself may play a minor role.

The presence of organic matter on the surface of soil increased the rate of entry of water. The indirect effect of surface organic matter may be important because of the maintenance of favorable conditions for biotic activities which tend to open channels in the soil. Several members state surface-litter filtered silty water and thereby increased the rate of entry of water while others contended the increased rate was due to the surface-litter preventing the puddling of the soil surface by raindrops.

Organic matter increased the water-holding capacity of soils although some contended the increase obtained from the addition of any amount within practical limits is almost negligible.

The rate of entry of water was greatest at the beginning of the application and decreased until approximately a steady rate was reached.

4. American geophysical union. Transactions of 1939 ... twentieth annual meeting, April 26 to 29, 1939, Washington, D.C. 4 parts. illus. Washington, D.C., Published by the National research council of the National academy of sciences, August 1939. 330.9 Am3 20th, 1939.

Part IV. Reports and papers, Section of hydrology, pp.484-740.
Of interest is the Report of the committee on physics of soil moisture, 1938-39 (The validity of the assumption that it is possible to produce different moisture-percentages in field-soils) E.J.Veihmeyer, chairman, pp.543-545.

Water applied to permeable soils in situ is rather quickly distributed and the soil throughout the portion wetted is raised to a certain moisture-content determined principally by the texture of the soil. Structure exerts much less influence upon its water-holding capacity than does texture. But structure has a decided effect upon the rate of infiltration of water into the soil.

Of interest is the Report of hydrologic advisory committee to the research division of the U.S.Soil Conservation Service. R.E.Horton, chairman, pp.612-614.

Purpose is to lay sound scientific hydrologic basis for problems such as flood-control on the ground surface, by increasing infiltration-capacity and reducing surface-run-off or better water-economy in land-use through the same means. No data is included.

5. Auten, J.T. The effect of forest burning and pasturing in the Ozarks on the water absorption of forest soils. U.S.Forest Expt.Sta.Central States.Sta.Note 16. 5pp., illus., mimeogr. Columbus, Ohio, 1934. 1.9 F6252S no. 16.

Absorption rates were determined on soils of forests and fields by pouring four successive one-liter portions of water into a 12-inch square wooden frame sealed with wet clay to the mineral soil from which the leaf litter had been removed. Detailed data (average of 100 tests each) gave rates of water absorption for each liter of water applied. The results showed a great difference in the absorptive capacity of soils from undisturbed woods compared to the capacity of either burned woods or open pasture. The rate of absorption was fairly constant for the former but diminished with each application of water to the latter.

6. Auten, J.T. Porosity and water absorption of forest soils. Jour.Agr. Res.46(11):997-1014, illus. June 1933. 1 Ag84J

Sites in Ohio, Indiana, Michigan, and Illinois were selected for sampling on the basis of no grazing or cutting of trees for at least fifty years and no recent fire damage. Samples were taken during an extremely dry period. Comparisons were made between forest and field soils. The soils were tested by driving five 2x12-inch brass tubes in sites to depths of 1, 3, and 8 inches below the soil surface and applying known quantities of water.

7. Ayres, Q.C. Engineering in erosion control. Civ.Engin.8(4):240-242, illus. Apr.1938. 290.8 C49

Since the object of engineering treatment for erosion control is to reduce surface run-off to a minimum, the interrelated factors which influence run-off should be clearly understood. Therefore, critical run-off in cubic feet per second equals the product of a coefficient of soil imperviousness by rainfall intensity by area of watershed, expressed by the formula, Q=CIA. A discussion of the factors follows including the absorptive power of the soil and infiltration rates.

8. Ayres, Q.C. Soil erosion and its control. 365pp., illus. New York and London, McGraw-Hill book co., inc., 1936 56.7 Ay7
Methods of control, pp.39-82.
On the subject, Absorption range of soils, the infiltration experiments of Musgrave on Marshall and Shelby silt loams are discussed and illustrations given. The rates 0.75 inch per hour for Marshall silt loam and 0.10 inch per hour for Shelby silt loam, represent about the extremes of perviousness and imperviousness likely to be encountered anywhere.

9. Ayres, Q.C., and Scoates, D. Land drainage and reclamation. 2d ed. 496pp., illus. New York and London, McGraw-Hill book co., inc., 1939 54 Ay7 ed.2
Control of soil erosion, pp.283-299.
In combating erosion, the resisting power to the chief eroding forces is determined largely by the infiltration and absorptive capacity of the soil and its inherent resistance to dislodgment. To what extent is absorption increased and percentage of run-off decreased is a question asked in judging or evaluating a control measure. Erosion-control measures seek to accomplish such results. Absorption may be increased by improving the infiltration rate and impounding the water where it falls, thus increasing the time of contact or the absorption opportunity. Data are given on run-off and soil losses from various cultural and cropping systems and the average number of days per year the soil is uncovered in different cropping systems.

10. Baird, R.W. Watershed and hydrologic studies on the Blacklands experimental watershed. Agr.Engin.20(7):273-276, illus. July 1939. 58.8 Ag83
The objectives of the hydrologic studies, the descriptions of area under study, and the hydrologic structures for making measurements including photographs are given. Infiltration values which vary with different watersheds and even in different parts of the same watershed are valuable in determining the effectiveness of conservation practices. In these studies a major attempt will be made to find the relation between the results of infiltration studies by means of tubes or rainfall-simulators from sampling small areas, and those results determined by the measurement of precipitation and run-off from larger natural areas.

11. Barnes, B.S. The structure of discharge-recession curves. Amer. Geophys.Union Trans.(1939)20, pt.4:721-725, illus.
330.9 Am3 20th, pt.4, 1939
Storm-discharge of streams in the upper Mississippi Valley consists of surface-flow and storm seepage. The latter emanates from water which has penetrated only the upper soil layers during a rainstorm or a thaw and has filtered more or less horizontally

through the soil to discharge into the stream-system by seepage. The author states, "The basins of the upper Mississippi Valley discharge such a small fraction of the total precipitation in the form of surface-flow that variations in the momentary intensity of the rainfall and daily changes in the infiltration-capacity of the surface-soil influence the amount of surface-run-off greatly. A decrease of a relatively small percentage in the amount of water which enters the ground can easily double the amount of water which does not enter. The total amount of storm-seepage, however, seems to be affected very little by the momentary rainfall-intensities of the storm." In the analysis of the record for the period July 6 to 22, 1935, of a 1500-square-mile area of the Iowa river basin above Marshalltown, 24-hour depletion factor curves for storm-seepage are given. A discussion accompanies these graphs. During winter and early spring the shape of the hydrograph of storm-seepage is affected by several factors and possibly by the increased viscosity of water in the soil at temperatures near the freezing point.

12. Barritt, N.W. Some effects of liming and crop growth on soil respiration. Internatl.Cong.Soil Sci., Oxford, Eng.Trans.(1935)3, v.1: 215-216. 56.09 In843 3d, v.1, 1935

A liming experiment on a very acid soil of sedimentary origin from Southeastern Nigeria. Liming increased respiration throughout the growing period. Crop growth diminished respiration of the unlimed soil but increased considerably that of limed soil. Various organic-supplying substances added to the soil resulted without exception in a higher rate of respiration in the limed soil.

13. Bates, C.G. A symposium on "Forest Influence" studies and methodology. Chron.Bot.5(2/3):184-188. Summer 1939. 450 C46

Specific measures of the infiltration capacity of soils are urgently needed for each and every "cover condition" which may occur upon each soil type. Under consideration are four methods of measuring infiltration, viz.(1)small plots with natural or artificial rains; (2)lysimeters; (3)measurements of accrued soil moisture; (4)analysis of surface hydrographs from small and uniformly covered watershed. The last method is often defective, especially if the cover conditions on the watershed are not uniform. Credit is given to P.B.Rowe for his simplified method using plots as small as 1x2 feet. Detailed descriptions of the method and equipment are given. Critical flood conditions may be traced sometimes to the existence of impermeable soils, soils readily "waterlogged," and other physical conditions which the best vegetative cover can modify only slightly.

14. Baver, L.D. Ewald Wollny--A pioneer in soil and water conservation research. Soil Sci.Soc.Amer.Proc.(1938)3:330-333. 1939. 56.9 S73 3d, 1938

In 1874 Wollny discovered that vegetation protected the soil from the impact of raindrops to such an extent that the non-capillary porosity was 34 to 53 percent higher than in unprotected soils. Tabular data are included. The loose, granular structure of the unprotected soils was not only broken down to cause a compaction of the soil, but the non-capillary porosity was also decreased by percolation of turbid water into the large pores with subsequent clogging up of these pores by fine particles. In his study of the factors determining percolation, the amount of percolate through a given soil depends upon the soil moisture at the time of the rain.

15. Baver, L.D. Soil characteristics influencing the movement and balance of soil moisture. Soil Sci.Soc.Amer.Proc.(1936)1:431-437, illus. 56.9 S63 1st, 1936

The characteristics of the surface layer greatly influence the initial infiltration of rainfall. The properties of the entire profile determine the rate and amount of percolation of absorbed rainfall through the soil column as well as the amount and movement of water retained by the soil. The author uses data of other investigators to prove his contentions. No original data are submitted.

16. Baver, L.D. Soil permeability in relation to non-capillary porosity. Soil Sci.Soc.Amer.Proc.(1938)3:52-56. 56.9 S63 3d, 1938

Soils with apparent low permeabilities always have small air capacities even as low as 2 percent of the entire soil volume, and such soils are almost completely impervious to water. A study of a wide variety of soils was made under different degrees of compaction determining capillary and non-capillary pore space, permeability, and pF moisture curves. The method used is explained. Data are submitted and graphs included showing the pF moisture curves of different sand fractions, the pF moisture curve as affected by compression, the pF moisture curve of different soils, as well as curves showing the relation of permeability to porosity. Results are fully discussed.

17. Baver, L.D. Soil porosity as an index of structure. Amer. Soil Survey Assoc.Bul.14:83-85. May 1933. 56.9 Am3

Paper given at thirteenth annual meeting of American soil survey association.

The author reviews methods used by foreign investigators for studying the porosity of the soil and gives a general discussion on air capacity of soils. A table of data giving "The relationship of various soil properties to the non-capillary porosity (Dejarenko)" and graphs illustrating the porosity of soil profiles are included.

18. Becking, J.H. De djaticultuur op Java. Een vergelijkend onderzoek naar de uitkomsten van verschillende verjongingsmethoden van den djati op Java. 304pp. Wageningen, 1928. 99.45 B38

Bibliography pp.295-301.

In Dutch. Title: Teakwood culture in Java

Plans of the experiments, pp.90-161.

Methods are compared for the rejuvenation of the teakwood forest-industry in Java. These are deeply concerned with air-capacity of the soil and the greater part of this chapter pertains to that phase of the subject. Data and illustrations are included. Burger's method for determining rates of infiltration of water into the soil by means of open cylinders is described.

19. Bennett,H.H. Dynamic action of rains in relation to erosion in the humid region. Amer.Geophys.Union Trans.(1934)15,pt.2:474-488, illus. 330.9 Am3 15th,pt.2,1934

The author discusses to great extent run-off and accompanying soil loss from soils at the experiment stations in several states and the multiplicity of variables affecting rate of soil erosion. He states "Soil-type alone introduces an almost endless variety of conditions that appreciably and even profoundly affect rates of absorption.***The texture of the surface-material,its inherent structure and consistency,markedly affect rates of absorption as do also the same characteristics expressed in the widely divergent sub-layers through the soil-profile down to and including the horizon of parent material." Data are given on run-off and erosion losses from the soils under study at the Erosion experiment stations.

20. Bennett,H.H. Soil conservation. 993 p.,illus. New York and London, McGraw-Hill book co.,inc.,1939. 56.7 B43S

The absorption of rainfall by the soil and assistance to infiltration by structural openings and fractures in the soil are considered,p.93.

Under the discussion of the effect of slope length on erosion and run-off and of rainfall intensity on soil and water losses, the infiltration rate is a prominent factor,pp.151-153.

The titles,Infiltration in relation to run-off,the Erosion process,and the Utilization of rainfall, are descriptive of the contents,pp.198-212.

Following infiltration rate data there is a discussion on water intake. The effects on infiltration by tillage,by turbidity of surface water,and by erosion, and methods for increasing infiltration are considered. Many other references to infiltration are interspersed throughout the book.

21. Bijl,J.G. Soil and water in the Haarlemmermeerpolder,Holland. Conf.Internatl.de Pedol.,Rome,Italy Proc.(1926)4,v.2:323-337, illus. 56.09 C764 4th,v.2,1926

Infiltration in the Haarlemmermeerpolder obtained from the difference between rainfall and evaporation and that determined by earlier investigators is discussed. The amount is determined on the season or yearly basis. The influence of infiltration on flora is taken up and particularly the effect upon the sugar content of sugar beets. Many maps and photographs,data on the yearly quantities of water pumped out of the area,and an illustration of the fresh water water-table in the subsoil are included.

22. Blaney,H.F. Rainfall penetration. 12 p.,illus. Sacramento, Calif.state print.off.,1934.
Reprint from Calif.Dept.Pub.Works Div.Water Res.Bul.46,ch.6, Ventura county investigation,1933.
A description is given of plots generally of Yolo loam series selected for rainfall penetration experiments in Ventura county, 1931-32. This article shows a method of calculating the annual rainfall penetration as shown by tables 17,A,and B for a number of locations with vegetative growth comprising citrus,deciduous, beans,grain,truck garden,bare land,brush,grass,and woods.
From the calculations not only an example of the rainfall penetration at one station for the period 1931-32 is given, but also a serial picture of the soil moisture deficiencies which are so important to initial infiltration.

23. Blaney,H.F.,Taylor,C.A.,and Young,A.A. Rainfall penetration and consumptive use of water in Santa Ana river valley and coastal plain. Calif.Dept.Pub.Works Div.Water Res.Bul.33,162p.,illus. Sacramento,1930. 290.9 C123
Factors in rainfall disposal,pp.37-104.
The deficiency of soil moisture below field capacity at the beginning of the rainy season is an important factor in limiting the amount of rainfall penetrating to ground water. Aside from the penetration due to local surface run-off,there can be no material penetration below the root zone until all of the soil within that zone has been supplied with its field capacity. These statements have proved conclusive from rainfall,soil moisture,and rainfall penetration measurements made from 1928 to 1930 on plots of soils in Orange county,Calif. Run-off was determined from plots of Ramona loam soil under different types of vegetative cover. Evaporation and transpiration losses determined are shown by graphs and tables of data. The rainfall penetration and the rainfall stored in the soil are included. The methods used are described in detail and illustrated.

24. Bodman,G.B. Factors affecting downward movement of water in soils. Amer.Soil Survey Assoc.Bul.17:33-36,processed. May 1936. 56.9 Am34
Report given at sixteenth annual meeting of Amer.Soil Survey Assoc.
The principles controlling simple cases of the downward movement of water in soil are briefly presented. Three types of movement have been considered:(1)movement through soils saturated throughout, (2)movement through soils unsaturated throughout,and (3) entry of water into columns from a region of complete saturation to one of unsaturation.
Downward movement of soil water as determined by laboratory measurement through columns of disturbed soil packed into tubes, by field experiments with undisturbed,deep soil columns in situ, and the effects of texture,apparent density,temperature,and water content of the soil upon such movement,are discussed.

25. Bodman, G.B. The variability of the permeability "constant" at low hydraulic gradient during saturated water flow in soils. Soil Sci. Soc.Amer.Proc.(1937)2:45-53,illus. 56.9 So3 v.2,1937

Soils of six different soil series,with pronounced dissimilarities in origin,chemical composition of clay fractions,and texture were taken from surface horizons and sieved before being packed into six pairs of 12-inch brass tubes 2 inches in diameter. Distilled water allowed to percolate through these soils was followed by a nutrient solution for 6 months. For all the soils,electrolyte-decreases in the percolate were rapid but relatively small whereas water permeability-decreases were relatively very large and long continued.

Explanation of the great decreases in saturated water-permeability of all the soils examined seems to lie in the early removal of electrolytes and subsequent gradual disperson and rearrangement of the clay particles so that the conducting pores are reduced in size more or less permanently.

Exchange of the percolating water for a nutrient solution having an electrical resistivity approximately equal to that of the corresponding original soil solution rapidly tends to increase the permeability of the more permeable soils, although the change may be only temporary.

26. Bodman,G.B.,and Harradine,F.F. Mean effective pore size and clay migration during water percolation in soils. Soil Sci.Soc.Amer. Proc.(1938)3:44-51. 56.9 So3 v.3,1938

Experiments were conducted on six different soils, each having a different texture.

The mean effective pore diameter was calculated but other measurements were made upon the soils themselves. The distribution of particle size classes in terms of the deviation of their percentage abundance from the mean is tabulated. Graphs show the final distribution of clay smaller than one micron with respect to depth for each soil column. The reduction of permeability with time in all columns of soil, partly by dispersion without migration, is fully discussed. The magnitudes of the pore diameters are associated with the occurrences of particle migration, but are unrelated to the absolute amounts of the latter, which have been measured by means of mechanical analyses,apparent densities,and cumulative percolation values. Decreases in water permeability with time appear to be the result of pore-blocking in the columns partly by dispersed and deeply migrated,and partly by locally dispersed and locally migrated fine particles. The intensity of migration depends upon both physical and chemical properties of the soil concerned.

27. Botkin, C.W. The effect of the constituents of alkali, fertilizers, and soil amendments on the permeability of certain fine-textured soils under irrigation. N.Mex.Agr.Expt.Sta.Bul.(Tech.)160. 61pp., illus. State College, Feb.1927. 100 N465 Bul.160

A laboratory study was made of the influence on the downward movement of water in Gila clay and clay loam by alkali, fertilizer, and certain soil amendments from determination of percolation rates. Sodium and potassium compounds, also clay and silt, retarded the penetration of water into the soils. The rate was increased by the following compounds shown in their relative decreasing effectiveness: aluminum sulphate, ferrous sulphate, aluminum chloride, calcium acid-phosphate, ferric sulphate, potassium acid-sulphate, ferric chloride, tannin, calcium acid-phosphate (commercial fertilizer), manure, and ammonium sulphate. Such substances increased the acidity and caused flocculating, both before and after percolation.

The low permeability of these fine-textured soils results from properties of the colloids. In the dispersed condition, there is a high adsorption of water, a large amount of swelling, a high fluidity, and an absence of flocky structure and normal pore space. Consequently a movement of water from or through the soil meets with great resistance and proceeds very slowly.

28. Botkin, C.W. The effects of acidifying amendments on impermeable soils. N.Mex.Agr.Expt.Sta.Bul.(Tech.)210. 18pp. State College, May 1933. 100 N465 Bul.210

Spots appearing in the fertile heavy, irrigated soils of Mesilla valley were found poor in tilth and permeability. Experiments were conducted to determine the effect of such amendments as gypsum, manure, acid phosphate, ferrous sulfate, aluminum sulfate, sulfur, ammonium sulfate, and sodium nitrate. Among other factors determined were the minutes required for water to penetrate to a depth of 6 centimeters of soil and the cubic centimeters of water percolating in a 24-hour period. The poorest permeability shown by data of table 1 was found in the 0 to 8-inch horizon, which contained a high percentage of fine-textured materials. In apparent effectiveness in improving permeability the amendments decrease in the following order: aluminum sulfate, sulfur, iron sulfate, ammonium sulfate, acid-phosphate, and calcium sulfate.

29. Bradfield, Richard. Soil conservation from the viewpoint of soil physics. Amer.Soc.Agron.Jour.29(2):85-92. Feb.1937. 4 Am34P

Under the author's question, "What can we do to insure good physical conditions in our arable soils?", the effects of grass or grass-legume crops on soil structure are discussed. A word-picture of the formation of soil granules and the entry of water into a soil having a granular structure is presented.

30. Brater,E.F. The unit hydrograph principle applied to small watersheds. Amer.Soc.Civ.Engin.Proc.65,(7)1191-1215,illus. Sept.1939. 290.8 Am3P v.65,1939

Studies at the Appalachian forest experiment station are fully described and used for basis of conclusions. Unit hydrographs and distribution graphs are given with data for run-off with descriptions of storms and water-sheds. The distribution graph is correlated with water-shed characteristics and application was made of the pluviograph which provided a means of tracing the quantitative changes in infiltration-capacity. The use of the unit hydrograph in estimating flood flows is outlined.

31. Browning,G.M. Changes in the erodibility of soils brought about by the application of organic matter. Soil Sci.Soc.Amer.Proc.(1937) 2:85-96,illus. 1938. 56.9 S3 v.2,1937

Also issued as Sci.paper no.195,W.Va.Agr.expt.sta.

Detailed account is given of experiments on infiltration and percolation rates from the effect of application of organic matter to different types of soils. The rates were significantly increased by the application of organic matter and the amount of the change varied considerably with different soils.

32. Buehrer,T.F. The movement of gases through the soil as a criterion of soil structure. Ariz.Agr.Expt.Sta.Tech.Bul.39. 57p.,illus. June 1932. 100 Ar4 Tech.bul39

The author describes a method of indicating the structure of a soil based upon the volume of flow rate of air through the soil column. An equation is derived for the mechanism of such flow. A comparison between the structure constant and the porosity of various soils is not simply linear as might be expected if all pores were continuous. While porosity measures the total void space in a granular system,it does not afford a measure of either the distribution nor the continuity of channels which contribute to the free passage of gases and liquids.

33. Burger,H. Die physikalische bodenuntersuchung,insbesondere die methoden zur bestimmung der luftkapazität. Conf.Internatl.de Pedol.Actes(1924)4,v.2:150-163. 1926. 56.09 C764 4th,v.2,1924

In German. Abstract in English,p.163,with the title,The investigation of the physical properties of the soil principally the air capacity.

The cylinder method for obtaining short blocks of undisturbed soil was used in the investigation. The author states that the examination of the air-capacity and the percolation of water gives a good idea of the structure of the soil. In soils under natural conditions there is a distinct relation between air-capacity and percolation.

Presupposing the same air-capacity,the percolation is high, if the greater pores in the soil form continuous tubes and channels(forest soil);the percolation is low when the larger pores are irregularly scattered and separated by small capillary pores (agricultural soil).

If forest soils and soils of natural meadows are under consideration, the percolation changes with the cross-section of the cylinder. On the other hand the cross-section is of little importance in the investigation of the percolation of agricultural soils. A criterion is lacking for fixing a definite cross-section of the cylinders and the depth to which the cylinders are to be driven into the soil.

34. Burr, W.W. The storage and use of soil moisture. Nebr.Agr.Expt. Sta.Bul.140. 20pp. Lincoln, Mar.1914. 100 N27 Bul.140
Also popular edition of Research bulletin no.5 and North Platte substation bulletin no.14.
The soil investigated is a very fine sandy loam (commonly known as hard land) of loess formation with native vegetation of buffalo and grama grasses located in the vicinity of North Platte. Getting water into the soil depends upon the condition of the surface soil at the time of the rain, the character and amount of the rain, and the amount of water already in the soil. Each of these factors is discussed. Cultivated surfaces have openings to hold the water until it can soak into the soil whereas surfaces not stirred have no such open spaces to catch the water. All gradations of resistance to the penetration of water are found from sand, offering little or no resistance, to gumbo where penetration is extremely slow. The more rapidly the water falls, the greater the run-off. The beating drops of water often puddle or clog the surface, making it more difficult for the water to enter. A very dry soil offers much greater resistance to the downward movement of water than does a moist soil. In addition to the above, evaporation, general cultivation, summer tillage, disking, and mulching are factors affecting the storage of moisture considered in this article.

35. Cole, J.S., and Mathews, O.R. Subsoil moisture under semiarid conditions. U.S.Dept.Agr.Tech.Bul.637. 70pp. Washington U.S.Govt.Print.Off., Apr.1939. 1 Ag84Te no.637
This treatise is supported with numerous tables of data and graphs. The extent of infiltration of water to the water table is discussed and the authors have found little or no infiltration of water in this semiarid region beyond the root zone. The accretions of water to the water table do not occur through the infiltration of water in the liquid form but may be due to vaporization and recondensation. The authors find that available moisture is completely removed to a lower depth under sod than under grain and the subsoil is generally not so dry under grain as under sod. Breaking up the upland sod in the Great Plains has not decreased the quantity of water in the subsoil. Although water infiltration rarely occurs beyond the root zone on the heavier agricultural soil of the Great Plains it does not occur on sandy soils.

36. Cook, H.L. The nature and controlling variables of the water erosion process. Soil Sci.Soc.Amer.Proc.(1936)1:487-494,illus. 1937. 56.9 So3 v.1,1936

One of the variables is infiltration and the need of developing rapid methods for its measurement is considered. The rates of infiltration depend upon some "standard" infiltration characteristic of the soil, moisture content of the soil, cultural practices principally as they affect compactures, vegetal covers, rates of rainfall, temperature, evapo-transpiration rates, and biological conditions of the soil. No supporting data are included.

37. Craib, I.J. Some aspects of soil moisture in the forest. Yale Forest School Bul.25. 62pp., illus. New Haven, Conn., 1929. 99.9 Y13 no.25

See pp.42-45. The apparatus and method are described for determining the rate of infiltration of water into forest and field soils in situ. Data of rates are given, also photographs of the apparatus installed in the forest. The important part that soil fauna plays in rendering soil permeable to water and the greater permeability of the upper layer of forest soil are considered.

38. De'Sigmond, A.A.J. Neuere erfahrungen über einige physikalische bodenbestimmungsmethoden. Conf.Internatl.de Pedol., Rome, Italy Proc.(1926)4, v.2:38-51. 56.09 C764 4th, v.2, 1926

The following is taken from the author's abstract in English, p.51, with the title, Some new experiments on some physical properties of soil.

The relative or variable properties pertaining to the soil permeability on the field and variations in soil moisture before and after irrigation were studied. The special apparatus is fully described. The apparatus for permeability permits determination of other values characteristic of soil structure, for example, penetration of the water from above to below or absolute water- and air-capacity of the soil. It can also be used as a lysimeter.

Tables of data and graphs are given in the original article and also an illustration of the equipment for studying the permeability of the soil in situ.

39. Disher, E.G., and Yoder, R.E. Sheet erosion studies on Cecil clay. Ala.Agr.Expt.Sta.Bul.245. 52pp., illus. Auburn, Nov.1936. 100 Al1 Bul.245

Studies determining the influence of various factors that contribute to the erosion of the soil through the agency of rainfall are reported. Both artificial and natural rainfall were used in the tests. Considering infiltration the authors state, "It is obvious that the extent of saturation of a soil with respect to water determines the rate and extent of further absorption and hence influences the amount of run-off and soil losses. Both the immediate absorptive capacity and the permeability are influenced

by the moisture content of the soil profile." The effect of slope was studied. Excessive run-off is caused by the soil profile being highly saturated with water(hence possessing a low rate of infiltration)or by rain falling at an intensity greatly exceeding the rate of infiltration. The plots for these studies were 15' x 50' and at slopes of 0,5,10,15,and 20 percent. Many tables of data and graphs covering the various tests are included.

40. Duley,F.L.,and Ackerman,F.G. Run-off and erosion from plots of different lengths. Jour.Agr.Res.48(6):505-510,illus. Mar.1934. 1 Ag84J

Small plots,3 feet wide,of four different lengths at a slope of 4 percent on Derby silty clay loam,were used for measurement of run-off either from natural rainfall or from application of water by means of sprinklers. Data are given for the various experiments showing greater absorption of water for increased length of plots with decreasing percentages of run-off.

41. Duley,F.L.,and Kelly,L.L. Effects of soil type,slope,and surface conditions on intake of water. Nebr.Agr.Expt.Sta.Res.Bul.112. 16pp.,illus. Lincoln,May 1939. 100 N27 Res.Bul.112

Infiltration rates were determined on several soil types under varying conditions. Results indicate the rate of infiltration may be varied between wide limits by changing the surface tillage, crop,or crop residue,or by repeating the application of water. This makes it difficult to select an infiltration rate which would be characteristic of any given soil. There may be far more variation between the rates obtained under different surface conditions on a single soil than would be shown by different soils having the same surface conditions. This may make it necessary to think of infiltration rates as characteristic of the surface conditions rather than of different soils. Details of the experiments,data covering the tests,and illustrations are included.

42. Durante,D. La classification dei terreni in rapporto allo sgrondo delle acque. Ital.Agr.74(5):353-360. May 1937. 16 Itl

In Italian. Title translated: Classification of soils in relation to the drainage of waters.

A study of the permeability of soils under various stratifications and slopes,such as permeable soil over an impermeable layer,permeable soil at various slopes,etc.

43. Eden,T. Soil erosion. Imp.Bur.Soil Sci.Tech.Commun.28. 30pp. Harpenden,Eng.,1933. 56.9 Im72

Under the subtitle,"Measurement of run-off and erosion," the results of other investigators on the effect of litter reducing the amount of run-off are discussed. The author states,"It is to be inferred that the agent most powerful in preventing silting up of the surface layer of the soil is vegetable remains that have not been completely decomposed and disorganized into humus,since grazed forest would contain a relatively high percentage of undifferentiated humic

matter which apparently has not the desired effect." Tables of supporting data are included and the effects of gradient and cultivation are discussed.

44. Engler, Arnold. Untersuchungen über den einfluss des waldes auf den stand der gewasser. 626pp. Zurich, Switz., 1919. (Mitt.Schweiz. Centralanst.Forstl.Versuchsw.bd.12). 99.9 Sch92

In German. Title translated: Investigations on the influence of forests on water resources.

The following is taken from abstract in Expt.Sta.Rec.44:417-41. 1921.

Studies on infiltration were made by observing the run-off in ditch systems on forested and unforested areas in Switzerland. Various meteorological conditions, soil types, and soil covers were considered. Usually more water found its way to the streams through the forested soils than through unforested soils, and voids were greater in the top layer of forested soils than of unforested soils. Frost action increased the porosity of the soil. Mild rainy winters increased the density of the soil layer. The permeability of the soil depends on its stratification and moisture content, and on the air pressure, temperature, type of vegetation, and the so-called resistance to weathering. The unforested soil retained more water even though both soils indicated the same moisture capacity. The favorable influence of forests on the water economy of the soil depends primarily on the greater porosity and permeability of these soils, and the influence of the forest itself rests merely in the indirect effect on the physical condition of the soils.

45. Enlow, C.R., and Musgrave, G.W. Grass and other thick-growing vegetation in erosion control. Effects on soil and water conservation. U.S.Dept.Agr.Yearbook 1938(Soils and Men):619-624, illus. 1 Ag84Y 1938

The effect of muddy water on infiltration rates is discussed and some data are included. Graphs are shown to illustrate the effect of organic matter upon the rate of infiltration of Clarion loam and they are also accompanied by a discussion. Data are given to show that the retarding effect on run-off by vegetation increases the amount of infiltration by giving a much greater time for water penetration on longer slopes than on shorter ones.

46. Fick, J.C. Erosion, plant growth and soil varieties. Farming in So. Africa 11(128):464-465. Nov.1936. 24 So842

General discussion of soil characteristics and causes of erosion. The fact that the top soil absorbs water readily is not sufficient; it must also permeate rapidly into the sub-soil. The application of manure has great value as a means of preventing the running-off of water and erosion. Although the increase in humus content of soil through fertilizing with farm manure is barely significant, such fertilizing does affect the soil structure in such a manner as to increase the capacity of the soil for absorbing water. Data are not given, but the conclusion was made from experiments conducted at the university of Pretoria and from observations on farms in the Orange Free State.

47. Finnell, H.H. The utilization of moisture on heavy soils of the southern Great Plains. Okla.Agr.Expt.Sta.Bul.190. 244pp. Stillwater, June 1929. 100 Ok4 Bul.190

A study of the effects of preparation methods, types of crops, and summer fallowing on the reception, retention, movement, and usage of soil moisture.

Handling of moisture in heavy soils could be largely overcome if cultural methods would improve receptive conditions for moisture penetration, thereby reducing the great evaporation losses.

Study shows contour tillage and the maintenance of organic matter to be the only practical means of promoting ready absorption.

Descriptions of the soil, climatic conditions, and methods are given as well as data in tabular form obtained from Amarillo silty clay loam during 1924-28. Data on soil moisture gains in selected wet seasons show the amount of water entering the soil was about the same in spring, summer or fall, but two factors seemed to effect the percentage of total which soaked in. When soils are cool the probable effectiveness is greater, and with an excessive amount of water the tendency is for greater efficiency. An average of about 20 percent of the annual rainfall becomes subsoil moisture in the heavy type of plains soil. Showers up to about 1/2 inch in size do not increase soil moisture unless they follow one another on consecutive days. The rate of gain of soil moisture was decreased by a high initial moisture content. Temperature is relatively unimportant to quantity of moisture stored or rate of gain in the soil.

48. Forchheimer, Philipp. The Echio dam. Amer.Soc.Civ.Engin.Trans. (1902)48:302-305. 290.9 Am3 v.48, 1902

Discussion of paper no.924 presented by Geo.S.Morison under the above title at the meeting of the American Society of Civil Engineers on Mar.5, 1902.

If sand is but slightly soiled by other substances the percolation of clay fills up the interstices between the grains and percolation becomes insignificant. Referring to the effect of temperature the author states, "At 90° F. speeds are two-thirds higher than they are at 50°." A formula for velocity and data for comparative purposes are presented.

49. Free, G.R., and Musgrave, G.W. A preliminary report of an infiltration study of some Piedmont and Coastal Plain soils. U.S.Soil Conserv.Serv.SCS-TP-13. 8pp., illus. May 1937. 1.96 R31P no.13

Musgrave's method for determining rates of infiltration of soils in situ is discussed and a photograph of the installation is included. Detailed data on rates determined for several soil types and comparative rates for clear water and turbid water for Ruston sandy loam and graphs showing comparative infiltration of certain soil types of southeastern United States, Marshall silt loam, and Shelby silt loam are given.

50. Freeman, V.M. Water-spreading as practiced by the Santa Clara water-conservation district, Ventura county, California. Amer. Geophy. Union Trans. (1936)17, pt.2:465-471, illus. 330.9 Am3 17th, pt.2, 1936

The soil of the spreading ground is Yolo fine sandy loam and the water table at the beginning of a spreading season is at a depth of 75 to 90 feet. No attempt is made to spread water containing more than 20 cubic feet of suspended matter per acre-foot. On the Saticoy spreading ground the natural growth of vegetation is left undisturbed and there has been no noticeable reduction in rate of percolation at the beginning of the season since 1929. A table of data is given showing the increased rate of percolation as a result of scarifying. A footnote to the table states "Starting April 4, estimated natural percolation increased 1 percent per day on account of warmer weather prevailing."

51. Gardner, W., and Widtsoe, J.A. The movement of soil moisture. Soil Sci. 11(3):215-232, illus. Mar. 1921. 56.8 So3

The article consists of a mathematical development of the problem together with experimental data in graphical form. These graphs show: The distribution of moisture in a series of horizontal tubes after the moisture had been allowed to move laterally about 24 inches from the end continuously saturated; distribution of moisture for approximately steady state for radial flow; the downward movement of a column of water through sand particles of various sizes; the distance of the water front from the source of supply as a function of the time; the distance of water front and time data where water was allowed to move into dry soil from moist soil of varying moisture content; the downward movement of moisture in a field soil; and others. The authors conclude with the assumptions: The inherent moisture conductivity in such a soil is independent of the moisture content; and the capillary potential is a linear function of the reciprocal of the moisture content.

52. Gerdel, R.W. Reciprocal relationships of texture, structure and erosion in some residual soils. Soil Sci. Soc. Amer. Proc. (1937)2: 537-545, illus. 1938. 56.9 So3 v.2, 1937

Variations in structure of Muskingum and Westmoreland silt loams and Belmont silty clay loams have been determined on the various types of soil aggregates present during the past growing season. As the season progresses there was a reduction in the amount of aggregated silt and clay greater than 0.05 mm. in size and an increase in the total amount of aggregated clay and aggregate stability. These indicate a greater moisture holding capacity for the soil in mid-summer than in early spring. The large size of the aggregates in the spring would be associated with greater non-capillary porosity and infiltration capacity. Although mixed-sized aggregates compact more readily than uniformed sized particles, compaction is not common in the spring.

53. Green,W.H.,and Ampt,G.A. The flow of air and water through soils. Jour.Agr.Sc./England/4(1):1-23,illus. May 1911. 10 J822
Tests on three soils were made in the laboratory and formulas were developed for applying to permeability of air and water and to percolation of water through the soils. Diagrams are given of tubes used in tests to assure soil uniformity by special method of compaction. Many illustrations are included.

54. Gustafson,A.F. Conservation of the soil. 312pp.,illus. New York and London,McGraw-Hill book co.,inc.,1937. 56.7 G97
Influence of the soil,pp.66-72.
The part that organic matter plays in keeping the soil in granular condition is discussed. Depth of the soil and water-holding capacity have a bearing on erosion. Infiltration capacity of the soil varies with its organic matter content. The sub-soil may be the most important single factor on erodibility of the soil. The infiltration capacity of a soil is the sum of the rate of percolation of water into the soil and the rate of downward movement of water by capillarity.

55. Harding,S.T. Direct accretions to ground-water from rainfall. Amer.Geophys.Union Trans.(1937)18,pt.2:368-371,illus. 330.9 Am3 18th,pt.2,1937
A brief general discussion of rainfall-penetration to the water-table,not including seepage from streams;conclusions are (1) amount of rainfall-penetration cannot be estimated on basis of mean annual rainfall alone, (2)in any locality penetration will vary widely from year to year and may occur only in years of above-average rainfall, (3)coarse-textured soils permit penetration under some conditions where no penetration would occur with heavier-textured soils, (4)shallow-rooted crops permit larger amounts of penetration than deeper-rooted crops, (5)the time of year during which rainfall occurs materially affects the amount of penetration, (6)rainfall during periods of plant dormancy is most effective.

56. Harding,S.T. Relation of the moisture equivalent of soils to the moisture properties under field conditions of irrigation. Soil Sci.8(4):303-312,illus. Oct.1919. 56.8 So3
Curves representing moisture equivalent and soil moisture in relation to different soil moisture capacities of the soil such as wilting of crop or maximum field capacity are given. Results of general field observations from many sources show the maximum depth of water to be about 1.25 inches per foot depth of soil retained under favorable conditions for the upper 5 feet. This indicates that under favorable soil conditions a single irrigation in excess of 6 to 8 inches of water will not be retained in the upper 5 or 6 feet of soil.

57. Harper, H.J. Soil structure and moisture movement. Soil Sci.Soc. Amer.Proc.(1937)2:15-20, illus. 56.9 So3 v.2,1937

Many contributers' views on the factors which affect soil porosity are presented. Soil porosity is favorable for the rapid movement of rain into the soil with very little run-off occurring. A macroscopic photograph of a crusted soil showing pore space is given with explanation of the soil's condition at the time of photographing. Factors affecting the rates of infiltration of water into the soil are considered, such as the effects of soluble salts, diameter of pore spaces, shape of the pore, flocculating by soluble material from the decay of organic matter, and others directly or indirectly contributing to the formation of soil structure.

58. Harper, H.J., and Volk, G.W. A method for the microscopic examination of the natural structure and pore space in soils. Soil Sci.Soc. Amer.Proc.(1936)1:39-42, illus. 1937. 56.9 So3 v.1,1936

The method provided for filling the non-capillary pore space in the soil with lacquer containing barite and then photographing. Several photographs of soils obtained by using a petrographic microscope are included.

59. Harris, F.S., and Jones, J.T. Soil moisture studies under dry-farming. Utah Agr.Expt.Sta.Bul.158. 51pp., illus. Logan, July 1917. 100 Utl Bul.158

Studies conducted from 1908 to 1916 on deep alluvial clay loam showed the moisture content of the soil the spring following disking of wheat stubble land to be less than stubble land not disked. Stubble holds the snow better than a disked or plowed surface, and fall cultivation apparently destroys surface cracks thus hindering the percolation of water to the lower depths. Moisture penetrated more rapidly in moist soil than in relatively dry soil. From .50 to 1.00 inch of rain was needed to penetrate the dry surface soil of fallow to the moist soil below. Of the total precipitation of 13.5 inches, 54 to 65 percent entered the soil. Upwards to 18 inches of precipitation was capable of being stored in the soil within 6 feet of the surface. More moisture was held in the upper 6 feet of spring-plowed than of fall-plowed fallow. Practically the same amount of moisture was found in land plowed shallow, deep, and subsoiled. Manure, especially when as much as 20 tons to the acre were added, increased the water-holding capacity of cropped soil and slightly increased that of the second foot of fallow. Numerous tables of data, presented as bar graphs and supporting the above conclusions, are given.

60. Harrison, J.T. On the subterranean water in the chalk formation of the upper Thames, and its relation to the supply of London. Inst.Civ.Engin.Proc.(1891)105:1-99, illus. 290.9 In74 v.105, 1891
See discussion, pp.81, 82, 98.
Speaking of the bed of the Thames, the author says, "There was an infiltration of water from the land adjoining." He also speaks of infiltration into fissures supplying water to form the tributaries to the river or by direct infiltration over a very extended surface.

61. Harvey, E.W. Nitrates and the weather. Amer.Fert.90(2):5-7, 24, 26. Jan.1939. 57.8 Am3
Soils differ greatly as to rate of water penetration. More penetration results from long continued rain of moderate intensity than from short heavy downpour of equal volume. After the first 2 or 3 inches of topsoil become saturated, further penetration of water is greatly slowed. The amount of water lost by surface run-off from a cultivated field often exceeds the amount penetrating the soil. Except in the case of extremely dry soils, the greater the content of moisture already in the soil or the more rapid the rainfall, the greater the percentage of run-off. The author discusses the amount of infiltration needed to replace the soil solution in the upper feet of soil. No experimental data on infiltration are included.

62. Hathaway, G.A. Estimating maximum flood-flow as a basis for the design of protective works. Amer.Geophys.Union Trans.(1939)20, pt.2: 195-203, illus. 330.9 Am3 20th, pt.2, 1939
Application of the infiltration theory to the derivation of design flood-hydrographs is discussed and examples of the method of approach are given.
A number of actual hydrographs for some streams of the Red River Basin were analyzed to determine the minimum average of infiltration-capacity. Estimates of run-off made for certain type storms over large areas for which the infiltration-capacity varies from 0.25 to 0.20 inch per hour are given. The author states, "Results obtained from experiments on small plots should reveal valuable data regarding the infiltration-characteristics of soils, but information on infiltration-capacities derived from rainfall-run-off data for large basins appears to have the most direct and practical application to general hydrological computations."

63. Havis, L., and Gourley, J.W. Soil organic matter and porosity of an orchard soil under different cultural systems. Soil sci.43(6): 413-420. June 1937. 56.8 So3
Water absorption was measured by driving 12-inch cylinders 2 inches in diameter into the soil to a uniform depth of 3.5 cm. They were kept full of water for 2 hours by pouring from a known volume. The amount remaining was determined and the average absorption in cubic centimeters per minute was obtained.

These determinations were made at a time the moisture content of all the soils was at approximately field capacity. The results were consistently comparable. In order of greatest volume weight and lowest rate of water absorption they were: cultivation, sod, and mulch. In each case, the difference between the results under cultivation and sod was greater than the difference between those under sod and mulch. Data and graphs are given.

64. Hazer, Allen. Some physical properties of sands and gravels, with special reference to their use in filtration. Mass. State Bd. Health Ann. Rpt. (1891/92)24:541-556, illus. 1893.
449.7 M38 24th, 1891/92

The frictional resistance of sand to water within certain limits of size of grain and rate of flow varied directly as the rate and as the depth of sand. Friction also varied with the temperature, being twice as great at the freezing point as at summer heat both for coarse and fine sands. With different sands the resistance varied inversely as the square of the effective size of the sand grain. It probably varied somewhat with the uniformity coefficient, but this was not proved. The formula for velocity and an example of its application are given. A table of data is given for the relative quantities of water at different temperatures passing through sand. Other data on rates are also included.

65. Hendrickson, B.H. A preliminary study of variability of run-off plots. U.S. Soil Conserv. Serv. Soil Conserv. 5(5):126-130, illus. Nov. 1939. 1.6 So38

From a set of recently established plots for the study of run-off rates, eight rains are reported which occurred in February and March, and classified as "slow" rates of rainfall, not exceeding 1 inch per hour for any 5-minute period. Such rainfall conditions are likely to produce run-off data of extreme variability, that is, rainfall intensities not much greater than soil infiltration rates may be expected to produce run-off data tending to reflect these infiltration rates. Thus these data are useful in detecting soil differences with respect to water intake. It does not follow that excessive-rate run-off, or run-off computed periodically or annually, will always be subject to interpretation in the same relative terms.

66. Hendrickson, B.H. The choking of pore-space in the soil and its relation to run-off and erosion. Amer. Geophys. Union Trans. (1934)15, pt.2:500-505. 330.9 Am3 15th, pt.2, 1934

Laboratory experiments performed in glass tubes 2 inches in diameter and fourteen inches long filled with soil determined the effect on rate of infiltration by silt- and clay-suspensions.

The pore-clogging effect of the thin films of sludge on the tops of the sand-columns varied consistently with the texture of the materials used. The packing together of silt and the packing and sticking together of the clay particles were about equal so far as resistance to movement of infiltration water was concerned. Tests following the laboratory experiments were made on plots of Kirvin fine sandy loam, 8 3/4 percent slope, 3 feet wide and 10 feet long to which muddied waters were applied at the upper end and the run-off measured. Data on all tests are included. The author concludes that the beating effect of the rain tends to throw the soil-material into suspension clogging the natural porosity of the soil as the water tries to enter.

67. Monin, S. La structure des sols. Internatl. Soc. Soil Sci. First Comm., Banger, Wales Trans. (1938) A:15-29. 56.9 In8Ic v.A, 1938
Bibliographie, pp. 28-29.
In French. Title: The structure of soils.
This contribution on moisture in the soil and its movement is based on the work of other investigators. Macroporosity and microporosity, diameter and formation of granules, the stability of the aggregate and mellowing of the soil, wetting, cohesion, dispersion of colloids, methods of improvement of the structure such as drainage, increasing cohesion and diminishing dispersion and wetting power are discussed. The relation between characteristics of the structure and practice of agriculture such as between structure and tillage, structure and plant growth, and characteristics which stabilize the structure of the soil are also considered.

68. Nester, J.B., and Shelton, F.A. The results of long-time fertilization and cropping practices upon the chemical and physical composition of Coastal Plain soils. Soil Sci. Soc. Amer. Proc. (1937) 2:201-205, illus. 1938. 56.9 So3 v.2, 1937
To change the reaction of the subsoil by lining, the lime must be mixed with it. Replaceable sodium greatly increased in the cropped soils from long-time fertilization. Sodium clays disperse and tend to move downward interfering with the internal drainage of the soil. In studying the influence of sea water flooding of soils on the eastern shore of Virginia a movement of clay from the soil was observed during the process of removing the salt from the soil by leaching. When gypsum was applied to the soil the movement of clay from the soil decreased.

69. Nitier, M. Summary of researches by Messrs. Müntz and Lainé on the control of irrigation according to the physical properties of soils. Internatl. Rev. Sci. and Prac. Agr. /Rome/ 622:974-978. July 1917. 24l In82
Abstract from original appearing in Bulletin de la Societé d'Encouragement pour l'Industrie Nationale, 127(2):386-398. Paris, Mar.-Apr. 1917 (not examined)

Mühtz and Laing conducted this study from 1905 to 1910 on the permeability of soils to water and divided soils into three classes based entirely on the permeability of soils(the infiltration rate). From the permeability the authors determined the width of the strip to be irrigated and the head of water to be applied to obtain the most efficient application of irrigation water. Data on several soils are given.

70. Horton,R.E. Analysis of run-off-plat experiments with varying infiltration-capacity. Amer.Geophys.Union Trans.(1939)20,pt.4: 693-711,illus. 330.9 Am3 20th,pt.4,1939

Data from experiments made by J.T.Neal at Missouri experiment station were used for analysis. Equations are developed for determination of the infiltration capacity for any given period during the test from the run-off-graph or from the data of the test. Tabulated analysis of one of Neal's experiments and a set of graphs showing the relation of infiltration-capacity to the rain duration are given. Similar types of data are given for time required to attain constant infiltration-capacity. Deductions are developed from Neal's data for depression storage,for relation of infiltration-capacity to soil moisture,for relation of initial infiltration capacity to antecedent rain, and for minimum infiltration-capacity. Analyses are given for hydrograph characteristics of Neal's experiments and many graphs illustrate analyses including infiltration or its factors.

71. Horton,R.E. Determination of infiltration-capacity for large drainage-basins. Amer.Geophys.Union Trans.(1937)18,pt.2:371-385,illus. 330.9 Am3 18th,pt.2,1937

Method for determination of infiltration-capacity for full-area stream-rises is given. Computations and graphs are shown for the hourly record of the storm at Vernon,Vermont,on Nov.3,1927;also examples for infiltration capacities of other areas in northeastern U.S. In estimating maximum flood-intensities expected in a given area,the infiltration-capacity is an important factor and the minimum infiltration-capacity should,in general,be used.

72. Horton,R.E. Discharge from catchment-areas in India,as affecting the waterways of bridges. Inst.Civ.Engin.Proc.(1923/24)217,pt.1: 387-395. 1924. 290.9 In74 v.217,1923/24

Discussion of paper no.4473 presented by G.E.Lillie under the above title at the meeting of the Institution of Civil Engineers Jan.22,1924.

Among factors affecting the flood-discharge from a catchment-basin are mentioned the following: (1)Initial condition of the soil. For example,a clay soil initially dry and thoroughly sun-cracked would temporarily absorb rainfall at a relatively rapid rate,but as the soil became moistened it swelled,closed the cracks, and the rate of infiltration greatly reduced. Again,a soil which

was under cultivation and normally highly permeable might have formed a crust by drying after previous rains through which infiltration proceeded slowly until the soil became thoroughly moistened. (2)Soil-temperature. Applying Slichter's formula, the relative rates of absorption or infiltration are given for various temperatures from 32° to 80°F. For example, for a midsummer flood, with a soil temperature of 80°F., the rate of absorption would be double that for a winter flood with the soil not frozen but at a temperature just above 32°F. The difference in infiltration capacity resulting from the effect of temperature might be sufficient to produce a flood of some magnitude. If the ground was frozen and there was no snow, infiltration would still take place, but at a slower rate, depending on the extent to which the pore-space in the soil was occupied by ice. (3)Rainfall quantity, duration, and areal distribution. Infiltration would be undoubtedly greater if water stood on the soil surface than if it were raining at such a rate that the soil could just absorb the rain as it fell. The loss by absorption or infiltration would be proportional to the length of overland flow. All of these factors are fully discussed.

73. Horton, R.E. Hydrologic aspects of the problem of stabilizing stream flow. Jour. Forestry 35(11):1015-1027, illus. Nov. 1937. 99.8 F768
Why infiltration rates of forested soils may be greater than those of unforested soils is explained. Discussions include the effects on infiltration from: perforations in the soil; natural depressions of the soil surface; lessened impact of raindrops on the soil; protective measures of leaf residue to the soil; diminished evaporation from the soil; lesser frost penetration; and the hydrological differences of forested and unforested area. Data and graphs are given on rainfall observations made in Illinois showing rainfall excesses by using assumed rates of infiltration. In this comprehensive article on stream-flow stabilization infiltration rates are a major factor.

74. Horton, R.E. Hydrologic interrelations of water and soils. Soil Sci. Soc. Amer. Proc. (1936)1:401-429, illus. 1937. 56.9 So3 v.1, 1936
Discussion with graphic illustrations of theory of analysis based on data from various investigators' research. Six methods of determining infiltration capacity are explained and discussed. This is a comprehensive review of infiltration of water into the soil and contains the development of several formulas.

75. Horton, R.E. The interpretation and application of run-off plat experiments with reference to soil erosion problems. Soil Sci. Soc. Amer. Proc. (1938)3:340-349, illus. 1939. 56.9 So3 v.3, 1938
The article describes methods for analysis and gives an interpretation of strip and plat experiments on a uniform and rational basis producing results of utmost scientific value. The phases of surface run-off phenomena are expressed in terms of definite independent variables. Graphs, formulas, and equations are developed, and applications discussed.

76. Horton, R.E. Maximum ground-water levels. Amer.Geophys.Union Trans.(1936)17,pt.2:344-357,illus. 330.9 Am3 17th,pt.2,1936.
Since the infiltration-capacity limits the rate of inflow, the limiting,maximum ground-water stage will be attained only if the ground-water has risen to such a stage that the ground-water outflow-rate equals the infiltration-capacity. This stage may never be reached in a given well or aquifer because rain-intensities exceeding infiltration-capacity are seldom of sufficient duration to bring the outflow-rate up to equality with the infiltration-capacity of the soil. The theory of limiting maximum ground-water stages is discussed and developed mathematically, considering the effect of various factors. The relations of winter and summer infiltration-capacities, transmission-capacities, and transmission ratios for a typical fertile loam soil are illustrated schematically and discussed. The effects of cultivation, sun-checking, insect perforations, and temperatures are considered. Several ground-water level records obtained at various locations are included.

77. Horton, R.E. The role of infiltration in the hydrologic cycle. Amer.Geophys.Union Trans.(1933)14:446-460. 330.9 Am3 14th,1933
Infiltration-capacity was determined from rainfall and run-off data from the Ralston creek(Iowa)drainage basin. The infiltration-capacity and field moisture capacity are complimentary, the first increasing and the second decreasing as the soil texture ranges from fine to coarse. Close interrelations exist between infiltration-capacity, field moisture capacity, and ground-water levels. Infiltration-capacity is generally close to the maximum during short storms following dry periods and close to the minimum during prolonged wet periods. Tabular data and graphs are included.

78. Horton, R.E. Surface run-off control. In Upstream Engineering Conference, Washington, D.C., 1936. Headwaters control and use, pp.16-41, illus., processed. Washington, U.S.Govt.print.off., 1937. 1 Ag84H
By surface run-off control, permanent reduction in the width of the ephemeral belt of drainage basins may be attained to some extent and there will be an increase in the soil moisture available for vegetation. Many factors are involved in surface run-off control and one of these is infiltration. The theory of infiltration and the relation of its capacity to surface run-off are discussed, using graphs for illustrations and presentation of data. Actual determinations of minimum infiltration-capacities of the soils at the Horton hydrologic laboratory are given. The type of surface or cover for a given soil may affect the infiltration-capacity; however, the high capacities of sodded soils are probably due in part to the presence of a considerable number of large openings into the soil surface. During short rain, infiltration-capacities are usually high for all types of soils initially dry but during long rains the subsoil rather than the soil surface may be the factor which determined the rate. Surface run-off and total run-off both decrease approximately the same proportion from an increase in infiltration-capacity. Other factors affecting surface-run-off are also considered.

79. Horton,R.E. Surface run-off phenomena. Horton Hydrological Lab.Pub.101. 73pp.,illus.,processed. Voorheesville,N.Y., Feb.1935. 290 H78 pt.1

Part 1. Analysis of the hydrograph.

Infiltration-capacities of three different areas are given from three different storms. Graphs and discussions are included. If the infiltration capacity is at its maximum value at the beginning of a rain it will decrease to a minimum value in a length of time depending on the soil texture. It will remain constant at its minimum value as long as the soil remains moist at or near its field moisture capacity. Upon drying out of the soil,the length of time for the infiltration capacity to return to its maximum value will generally be greater than the length of time required during a storm for it to pass from its maximum value to its minimum value.

80. Houk,I.E. Rainfall and run-off in the Miami Valley. Miami Conserv. Dist.Tech.Rpt.8. 234pp.,illus. Dayton,O.,1921. 290 M58 pt.8

Presenting the results of rainfall and run-off investigations in connection with the Miami flood control project was the purpose of the report. Detailed descriptions are given for the various factors such as rainfall,soil properties including moisture,equipment used for tests and measurements,run-off from plot tests,etc. Data collected on rainfall,run-off,and temperatures for various drainage areas are considered. Many graphs representing the hydrology of the Mad river valley for different years are given. Many curves are given for various conditions showing the average relations between rates of rainfall and run-off and others showing the total rainfall, run-off, and retention up to any given instant for the Moraine park experiments. Tabular data are also furnished. The article is comprehensive.

81. Hoyt,W.G. Rainfall and run-off studies. U.S.Geol.Survey. Water-Supply Paper 838:486-594. 1938 407 G29W

Studies of rainfall and run-off from the area contributing to the tributaries of the Ohio river causing the flood of January-February 1937 are described. The method of analysis is given and the results discussed. The average infiltration capacity during the total storm period in the Ohio river basin approximated 0.04 inch per hour. Weekly records of rainfall and run-off for several hundred stations representing drainage areas(size given in square miles)are included. Also a map is given showing approximate infiltration-capacities during this flood period. The area is divided into single or small groups of drainage basins to permit more accurate analysis. A table representing approximately 100 stations gives the determination of the approximate infiltration capacity for periods of 1 week or more during the period of the flood. Many graphs are given illustrating meteorologic and hydrologic data relating to various areas of the watershed. A table of data showing precipitation,run-off,and infiltration in inches for six basins of tributaries in the western part of the Ohio river basin is also given.

82. Hoyt,W.G.,and others. Studies of relations of rainfall and run-off in the United States. U.S.Geol.Survey. Water-Supply Paper 772. 301pp.,illus. Washington,U.S.Govt.print.off.,1936. 407 G29W n .772

An investigation of relations between annual and monthly precipitation,temperature,evaporation,transpiration,direct surface run-off,ground-water run- ff,and infiltration as a basis for the quantitative analysis of the hydrologic cycle over broad areas and of trends and changes therein,and of relations between storm precipitation and direct surface run-off. The article is largely devoted to unit-hydrograph analyses of surface-run-off and unit-hydrograph method and storm transposition in flood problems. Numerous tables of data for various drainage basins and hydrographs are included.

83. Huberty,M.R. Effect of soil characteristics on plant development in relation to water conservation. Soil Sci.Soc.Amer.Proc.(1936)1: 439-446. 1937. 56.9 So3 v.1,1936

"Literature cited,"pp.443-446.

Texture not only affects infiltration but also the quantity of water that can be stored in the unit. Structure has a very decided effect on water infiltration and influences the amount of water held at field capacity. The various soil characteristics are discussed.

84. Hugues,C. Richerche di tecnica colturale sulla filtrazione dell' acqua nei terreni agrari. Gior.de Risic.9(5):74-78. May 1919. 59.3 G43

Reprinted from Il Villaggio,April 26,1919.

In Italian. Title: Investigation on the percolation of water in agricultural soils.

Abstract in English appears in Internatl.Rev.Sci.and Pract.Agr. 10(10):1077-1080. 1919.

Soils were placed in tubes,water applied and the percolate was measured by using Mariotte flasks. The rate of infiltration was determined for water in comparison to sodium carbonate solutions. For a standard quantity,it required for penetration of the soil, 39 min.,18 sec.for water,32 min.,45 sec.for 1% Na_2CO_3 solution, and 28 min.,0 sec.for 25% Na_2CO_3 solution. Various soils were tested and found to give somewhat similar proportionate results. The accepted rate of 1.20 litres per second per hectare for infiltration must vary with the infiltration capacity of each irrigated soil. Cultivation facilitates the descent of rain or irrigation water to the roots or water-reserves in the sub-soil. By infiltration of water into the ground is meant the more or less variable capacity of soils for allowing water to percolate more or less rapidly down from the surface to the more deeply-seated layers. Data are included on numerous soil moisture tests determining the relation between the depth of penetration of rainfall and the quantity of rainfall for various soils in situ.

85. Israelsen, O.W. Irrigation principles and practices. 422pp., illus. New York, John Wiley & sons, inc., 1932. 55 Is7
The Movement of water in soils, pp.189-212.
The water transmission factors for soils and the conductivity of saturated soils are considered with supporting data. Permeability and specific water-conductivity field tests of different saturated soils are tabulated from experiments by the author during 1917 to 1923 by the cylinder and plat methods. These methods are described in detail.

86. Israelsen, O.W. Studies on capacities of soils for irrigation water and on a new method of determining volume weight. Jour. Agr.Res.13(1):1-35, illus. Jan.1918. 1 Ag84J
Thousands of samples were taken from four different locations to depths of six feet or more. Volume weights without distrubing the structure and moisture equivalents were determined on the disturbed samples secured four days after irrigation. Usually only small gains in soil moisture occurred from heavy irrigations. Pore spaces vary with the soil approximately 40 percent in silt loam soils having fine sandy loam subsoils, 51 in silt loams, 58 in clay loams, and 66 percent in clays. Observations indicated that percentages of pore space filled by water immediately after irrigation, increase as the fineness of soil textures increases. Correlations were made between moisture equivalent and the amount of water held by the soil after irrigation. Numerous tables of data and graphs are presented.

87. Jacot, A.P. Soil populations. Sci.Monthly 42(3):247-251, illus. Mar.1936. 470 Sci.23
The minute segmented-animals (arthropods) so numerous and generally distributed in organic soils as to be of outstanding importance in making and keeping the soil full of minute channels make it possible for rainwater to enter it instead of running off the surface. The saprophytic (deadwood-eating) microarthropods are less than a millimeter in breadth and microchannel the roots and small rootlets. There is also a group of minute arthropods which burrow about in the soil, filling it with minute channels which have no particular relation to the rootlets. Together they form an intricate system for water passage-ways. The action of other types of animals populating the soil is also discussed. No quantitative data are given.

88. Jenny, H., and Leonard, C.D. Functional relationships between soil properties and rainfall. Soil Sci.38(5):363-381, illus. Nov.1934. 56.8 So3
Numerous samples of topsoil from Colorado, Kansas, and Missouri along the 11°C isotherm were collected from fairly uniform parent material consisting primarily of wind-blown deposits. Samples were taken from virgin grass, pasture, and cultivated fields. The zone of

carbonate accumulation decreases at a rate of 2.5 inches for each inch of rainfall. Under high rainfall the formation of colloidal clay increases at a rate of about 1 percent per inch of rainfall. Soil aridity changes regularly from pH 7.8 in the semi-arid region to pH 5.2 in the semi-humid one. Many tables of data and graphs illustrating conclusions are given.

89. Johnson,T.W.,and Taliaferro,D.B. Flow of air and natural gas through porous media. U.S.Bur.Mines Tech.Paper 592,55pp. Washington,U.S. Govt.print.off.,1938.

A general equation for the flow of gas through consolidated and unconsolidated sands is given. Porosity alone is not a measure of permeability although other factors being constant,permeability increases with porosity. Grain size,an important factor in permeability,and shape of the grain influence the flow;round grains permit greater flow than angular.

90. Kachinsky,N.A. Neue methoden zur bestimmung einiger physikalischen eigenschaften des bodens. Internatl.Cong.Soil Sci.,Leningrad-Moscow,U.S.S.R.First Comm.Proc.and Papers(1930)2:129-160,illus. 56.09 In842P 2d,1930

In German. Title: New methods for determining some physical properties of the soil.

Wasserdurchlassigkeit des bodens,pp.135-144,describes a method of infiltration of water through undisturbed soil and is illustrated.

91. Kachinsky,N.A. Vliania formi e velitchini zalivaemikh pleschadok na vodopronitzaiemost pochvi. Pedology 31(1):62-76,illus. 1936. 57.8 P34

In Russian. Title: Influence of form and size of the flooded area on infiltration. Author's abstract in German appears on pp.77-78.

Experiments on small areas,100x100 centimeters or smaller were made. Illustrations show the depth of water penetration into the soil and the effect of roots,fissures and other types of holes in the soil on the character of penetration. Many graphs and several tables of data are given. Table 1,translated title is, "Infiltration of soil in mm. dependent upon area under irrigation (temperature 10° C.)."

92. Karraker,P.E. The effect of the initial moisture in a soil on moisture movement. Soil Sci.10(2):143-152. Aug.1920. 56.8 So3

Tests on soils packed in tubes designed for moisture-movement work indicated water moved 1.56 times faster in saturated sand than sand air-dry at the initial. Small differences in the initial moisture content had no significant effect on the rate of penetration. The movement of water in oven or air-dry soil was as rapid as in soil with a small initial moisture content. Description and illustration of apparatus and extensive experimental data are included.

93. Keen, B.A. The physical properties of the soil. 380pp., illus. London /etc./ Longmans, Green & co., 1931. 56.43 K25P
Distribution and movement of water in the soil, pp.89-128.
Primarily a mathematical treatise of the subject supported in some phases by experimental data. This applies especially to "the geometry of the pore space and the associated moisture distribution." Fully illustrated by graphs and sketches. One graph covering a 70-day period shows the consolidation of tilth of a rotary-cultivated soil at the Rothamsted station, expressed in inches, with time expressed in days. The consolidation is fairly uniform and rapid for the first 10 to 15 days and of little significance after 20 to 30 days.

94. Kell, W.V., and Brown, G.F. Strip cropping for soil conservation. U.S.Dept.Agr.Farmers' Bul.1776 rev.ed., 38pp., illus. Washington, U.S.Govt.print.off., July 1938. 1 Ag84F no.1776, rev.
Effect on absorption of rainfall by the soil through root growth and similarly the effect on infiltration by dense vegetation growth are considered; also the clarification of muddy water by the filter action of close growing crops and the sealing action of soil pore space by small soil particles suspended in water. Photographs and illustrations of strip cropping are included.

95. King, F.H. Principles and conditions of movements of ground water. U.S.Geol.Survey Ann.Rpt.(1898)19, pt.2:59-294, illus.
407 G29R 19, pt.2, 1898
This is a comprehensive study. The amount of water stored in the ground, depth to which water penetrates, percentage of precipitation penetrating the soil, general movements of the water such as gravitational, thermal, and capillary movements, rate of flow of water through sand and rock, and the flow of air, kerosene, and water through porous media are discussed at some length. The method of determining the diameter of sand and soil is of importance to the study of infiltration rates as well as the experiments of infiltration set forth in the report such as the rate of seepage into the infiltration pipes of the Crystal Springs Land and Water Company, the percolation of water into undisturbed field soil, and the time required to lower the ground-water level by a system of infiltration pipes.

96. Kittredge, J., Jr. Comparative infiltration in forest and open. Jour.Forestry 36(11):1156-1157. Nov.1938. 99.8 F768
General information on determinations of infiltration during October over a six-year period at Berkeley, Calif. The open space used was the fire-break which was burned over annually. Three hundred and thirty-seven (337) paired determinations were made using the method devised by J.T.Auten. The excess infiltration under the forest seems largely attributable to the influence of the forest cover. Data and discussion of results are included.

97. Knight, H.G., and Hendrickson, B.H. The infiltration and storage of rainfall: conservation and use of soil moisture. U.S.Bur. Chem.and Soils, Soil Erosion Expt.Sta.No.4, Tyler, Texas, Ann.Prog. Rpt.1934:48-60.

This report is not available for general distribution.

The infiltration rates were determined on three 1/100 acre plots of Kirvin fine sandy loam with 8 3/4 percent slope. Two plots were in cotton, one of which had been previously desurfaced, and the third was a plot of Bermuda sod. Graphs were constructed to determine the infiltration rates. Maximum infiltration period reported was 60 minutes. Comparisons were made for loose, settled and saturated conditions of the soil for each plot. Table of data given with title, "Actual infiltration rates for Kirvin fine sandy loam."

96. Knorr, Fritz. Experiments with crops under fall irrigation at the Scotts Bluff reclamation project experiment farm. U.S.Dept.Agr. Bul.133. 17pp., illus. Washington, U.S.Govt.print.off., Sept.1914. 1 Ag84B no.133

A set of experiments on sandy loam underlain at a variable depth of 3 to 7 feet with a stratum of clay at Scotts Bluff, Nebraska, was conducted with crops of wheat, barley, oats, potatoes, sugar beets, and corn. Half of the area selected was irrigated so as to saturate it to as great a depth as possible in the fall of each year. The other half was not irrigated in the fall, but in the spring the entire area was irrigated and the soil was allowed to saturate to a depth of 18 inches. In order to obtain this condition, the water was permitted to flow for a longer period over the portion which was not fall-irrigated. After irrigation dry soil was found at a depth of 24 inches but on the fall-irrigated area a good supply of water penetrated to a depth of 6 feet. Average yields of all crops were much higher for the fall-irrigated areas. Complete data on rainfall, soil moisture control, crop growth and yields are given.

99. Kohnke, Helmut. A method for studying infiltration. Soil Sci.Soc. Amer.Proc.(1938)3:296-303, illus. 56.9 So3 v.3,1938

Other investigators' methods on infiltration rates of water into the soil are reviewed. A description and a detailed illustration are given of the method used for determining the infiltration rates on some soils in the northwestern Appalachian experimental watershed. The rates were somewhat higher than those computed for the entire watershed. Graphs illustrating the deviations from the mean infiltration rates of each group and data are included.

100. Kohnke,H.,Dreibelbis,F.R.,and Davidson,J.M. A survey and discussion of lysimeters and a bibliography on their construction and performance. U.S.Dept.Agr.Misc.Pub.372. 67pp.,illus. Washington,U.S. Govt.print.off.,1940. 1 Ag84M no.372

A bibliography comprising approximately 500 references on the subject of the lysimeter carries a new departure in regard to the contents of the article referred. This is accomplished by means of symbols(letters) which designate the information in the reference concerning construction of the lysimeter;quantity of leachate; composition of leachate or soil; comparison with other investigators' work; a general discussion.

The history of lysimeters is set forth in tabular form. A review is given of the types of lysimeters including a large soil-block lysimeter with self-recording weighing mechanism described in detail, recently installed near Coshocton,Ohio. Records of continuous weights of lysimeters permit analyzing for infiltration as well as other factors such as transpiration,evaporation, and amount of rainfall.

101. Knoblauch,H.C.,and Haynes,J.L. Run-off under different systems of grassland management. U.S.Soil Conserv.Serv.Soil Conserv.5(10): 256-258. Apr.1940. 1.6 So35

Investigations at Beemerville,N.J.,by the Soil Conservation Service determining soil and water losses under various agricultural practices related to dairy farming show permeability of the soil to be a dominating factor. Records indicate that water loss from continuously grazed pasture land somewhat exceeded that of corn land throughout the year. Individual storm records show,however,that run-off starts from corn or corn-fallow plots before it does from grassland. With sustained rainfall causing run-off, the initial effect of run-off detention by grass cover frequently is overshadowed by the effect of higher permeability of corn ground causing the gross totals to reflect a slightly higher run-off under continuously grazed pastures. The records also indicate a much greater absorption of rainfall by grass-legume silage plots than for either corn silage plots or grazed plots. Since the structure of soil under grass-legume silage plots is undisturbed and more porous, the high permeability,the high initial retention by canopy interception,and resistance to overland flow by vegetation are reflected in a very low percentage run-off. Description of the soil and plots, and data of the experiments are given.

102. Koshal,R.S. The effects of rainfall and temperature on percolation through drain gauges. Jour.Agr.Sci./England/24(1):105-135,illus. Jan.1934. 10 J822

In consultation with R.A.Fisher.

Data from the drain gauges at Rothamsted were used to study the effects of meteorological conditions on the quantity of leachate. The article consists primarily of a statistical analysis of results, obtained from the 20-,40-,and 60-inch gauges over the period, 1878-1932. Regressions of rainfall on temperature and drainage on temperature are discussed at length.

103. Krawkow,S. Über die prozesse der bewegung des wassers under der salzlosungen im boden. Jour.f.Landw.483:209-222. Oct.1900 18 J825

In German. Title: Concerning the process of water and salt solution movement in the soil.

Tests on 2 soils(analyses given in text)were conducted in 3 glass tubes 2 m. long and 3.6 cm. diameter. Several tables of data are given showing the depth of penetration of water from the start of the test for periods ranging from 1 minute to 2 days. To investigate the movement of salt solutions in the soil,tests were made in a similar manner using 7 different salts,comprising 2 phospates,2 sulphates,a nitrate,chloride,and a carbonate. In general,penetration only to depths of 45 centimeters or less were considered.

104. Laatsch,Willy. Die durchfeuchtungswerte der deutschen sandböden. Ernähr.der Pflanze 34(1):3-8,20,illus. Jan.1938. 57.8 Er6

In German. Title: Water relationships in German sand soils. English summary,p.20.

The author shows how lysimeter data may be used for the calculation of infiltration values for localities in Germany and Hungary. Average values for the different months and for the local growing season are illustrated by graphs. "Infiltration = precipitation - evaporation."

105. Laatsch,Willy. Die klimatisch bedingten durchfeuchtungsunterschiede der deutschen böden. Ernähr.der Pflanze 34(3):37-38,54-55. Feb.1938. 57.8 Er6

Map included. English summary,pp.54-55.

In German. Title: The moisture status of German soils as influenced by climatic factors.

Infiltration value = rainfall - evaporation. Data from lysimeters and 120 meteorological stations are used with the formula evaporation in mm.=saturation deficit x wind factor x soil factor to work out the infiltration values for sandy soils with grass cover throughout Germany. The soil factor used for such soils is 180 and the wind factor is 1. These values are compared with climatic and vegetational zones in Germany with striking agreement. Tabular data included.

106. Langbein,W.B. Some channel-storage studies and their application to the determination of infiltration. Amer.Geophys.Union Trans. (1938)19,pt.1:435-447,illus. 330.9 Am3 19th,pt.1,1938.

Formulas are developed for the computation of the infiltration-capacity and data submitted. An example is given for Greenville creek basin above Bradford,Ohio,for the period Dec.27,1936 to Jan.5,1937. A discussion by L.L.Harrold and the author concludes the article.

107. Leach,H.R.,Cook,H.L.,and Horton,R.E. Storm-flow prediction. Amer.Geophys.Union Trans.(1933)14:435-446,illus.
330.9 Am3 14th,1933

Application of the "index-area method" comprises the greater part of this article including numerous graphs and tables of data. Relations between index-area and main-area run-off bring in the factor infiltration. For a given drainage-basin in a given storm infiltration is determined by plotting diagrams of rainfall intensity and rainfall-excess. Sixteen storms were studied in the Ralston creek drainage basin and the infiltration capacities determined. A determination of infiltration-capacity for an index-area is a good indicator of the infiltration-capacity pertaining to the larger area. The apparent advantages of this method is that the run-off estimate is based on that part of the rain which actually produces surface run-off and the marked effects of varying absorptive capacity of the soil are directly taken into account for each storm instead of being averaged as in cases where run-off coefficients or a normal run-off rainfall relation-curve is used.

108. Lee,C.H. The interpretation of water-levels in wells and test-holes. Amer.Geophys.Union Trans.(1934) 15,pt.2:540-554,illus.
330.9 Am3 15th,pt.2,1934

Many graphs are given for the mechanical analyses of silts,clays, sands,and gravel with increasing ranges of permeability coefficients. Rainfall infiltration is shown as one of the graphs comprising typical annual water-table fluctuations. A water-table will form only in permeable material and cannot exist in an impermeable material such as dense clay,even though saturated.

109. Lewis,M.R. Movement of moisture in soil. Oreg.State Hort.Soc.Proc. (1936)28:164-172. 81 Or32 28th,1936

The differences between soils relative to the rate of infiltration of water into the soil are very much greater than the differences in respect to capillary movement. The manner in which infiltration takes place is expressed. Data are given from tests on Willamette silty clay loam,Melbourne clay loam under cultivation for many years,and virgin soil. Infiltration tests were also made on Chehalis loam which had been farmed to a rotation of crops. Concerning irrigation the author says that infiltration is too irregular to assume that all parts of a field are properly irrigated even if water reaches all of the surface. In one test of soil under irrigation, the soil became so nearly impervious that the moisture content below the first foot not only did not increase but sometimes actually decreased while water was still flowing over the surface. No tabulated data are included.

110. Lewis,M.R. The rate of infiltration of water in irrigation practice. Amer.Geophys.Union Trans.(1937)18,pt.2:361-368,illus.
330.9 Am3 18th,pt.2,1937

Review of infiltration studies made by the author since 1926. Experiments were started with galvanized cylinders,18 inches in diameter,set into the soil to a depth of 3 to 4 inches. Fresh water was applied and time noted for infiltration. Reference is made to J.C.Marr's comparative infiltration data obtained on two 1/6 acre areas. Infiltration tests were made at Hermiston,Oregon,with concentric cylinders,18 inches and 6 inches in diameter. Data including time for infiltration of 2 inches of water and detailed descriptions of apparatus are given. Depths infiltrated ranged from 0.48 to 20 inches for the first hour and from 0.53 to 80 inches total for the first 5 hours.

111. Lewis,M.R.,and Milne,W.E. Analysis of border irrigation. Agr.Engin. 19(6):267-272,illus. June 1938. 58.8 Ag83

A discussion on infiltration from the standpoint of irrigation. Infiltration was studied from data on the rate of advance for a total of 265 individual irrigations. Data and curves are given showing the length of border permissible in irrigation with certain size stream flow.

112. Lewis,M.R.,and Neal,E.H. The rate of infiltration of water into soils. Agr.Engin.9(5):147-148,illus. May 1928. 58.8 Ag83

Infiltration rates of Palouse silt loam were determined by mixing the soil and placing in tanks without changing the volume weight. The tanks were 36 inches deep and 3,6,12 and 20 inches in diameter, each equipped with an outlet pipe at the bottom. A photograph of equipment is shown. Failing to obtain consistent results, the tanks were filled with soil three different times. The authors concluded the size of the container had no effect upon the rate except as it affected the amount of settlement and therefore the porosity,but the effect of porosity on the rate of infiltration was evidently very great. Tabulated data are given and also a graph showing rate of infiltration into Palouse silt loam of varying porosity.

113. Lewis,M.R.,and Powers,W.L. A study of factors affecting infiltration. Soil Sci.Soc.Amer.Proc.(1938)3:334-339. 1939.
56.9 So3 V.3,1938

The rate of entrance of water at the soil surface or infiltration should be distinguished from ultimate rate of movement through a wet soil mass. A chart illustrates those factors influencing the infiltration capacity at a given time and point,and those influencing the average infiltration capacity over a considerable area and time. A table of data is given of the effect of soil type and cover on infiltration in the field. The effect of soil temperature,soil cover and type,confined air in the soil,hydrostatic head of water used in determining rates,removal of the soil block from its natural position, and the duration of the application of water to the soil are discussed as factors affecting infiltration capacity.

114. Lowdermilk,W.C. Influence of forest litter on run-off,percolation, and erosion. Jour.Forestry 28(4):474-491. Apr.1930. 99.8 F768

Specially constructed tanks for testing soils for run-off by assimilated rainfall are described and illustrated. Comparative rates were obtained by using clear and muddy water. The muddy water greatly reduced the rate of infiltration. The procedure is described in detail and tables of data are included. The formation of a fine-textured layer at the surface of a bare soil as a result of filtering suspended particles from percolating muddy water is concluded to be the decisive condition which increases the surficial run-off from bare surfaces.

115. Lowdermilk,W.C. Studies of the role of forest vegetation in surficial run-off and soil erosion. Agr.Engin.12(4):107-112,illus. Apr.1931. 58.8 Ag83

Factors affecting run-off are considered. Photographs of the testing equipment are shown. Data are given in tabular form for some of the tests with descriptions of the soils,plots,and testing procedures. The macro-structural features of the soil are discussed. Assimulated rainfall at intensities up to 4 inches per hour was applied to tank-plots 3 feet deep having a soil-area of 20 square feet. The slope was adjustable from 5 to 20 percent. The effect of litter on run-off prevention was studied.

116. Lowdermilk,W.C. Water-intake of saturated soils. Amer.Geophys. Union Trans.(1937)18,pt.2:355-361,illus. 330.9 Am3 18th,pt.2,1937

Factors of infiltration are discussed and conclusions are based on previously reported experimental evidence. Graphic figures and tables give comparisons of the disposition of precipitation in lysimeters.

117. Lutz,J.F. The physico-chemical properties of soils affecting soil erosion. Mo.Agr.Expt.Sta.Res.Bul.212. 45pp.,illus. Columbia, July 1934. 100 M693 Res.bul.212

Davidson clay, a highly permeable soil,and Iredell sandy clay loam,a highly impermeable soil,found in adjoining areas in the Southeast,were studied to determine why the former was fairly non-erodible and the latter highly erodible. One of the principal differences between erosive and non-erosive soils is the degree of aggregation of the finer particles into large,stable granules. The high state of aggregation of the Davidson soil is due to the flocculated and non-hydrated condition of the colloidal fraction. Hydration of the Iredell colloid is responsible for the low state of aggregation and impermeability of the natural soil. The characteristics of various colloids were also studied and their order of swelling was Bentonite> Putnam> Iredell> Davidson. Tabular data,graphs,and other illustrations are included.

118. Lutz, J.F. The relation of soil erosion to certain inherent soil properties. Soil Sci.40(6):439-457, illus. Dec.1935.
56.3 So3

The physical and chemical properties of soils play an important role in determining the susceptibility of a soil to erosion. The order of swelling was Bentonite> Putnam> Iredell> Davidson, with no swelling exhibited by the latter. The Ca, Ba, and H decreased swelling in the order named, but K, Na, and Li cations showed no definite order. Permeability of the different clay membranes was in the order: H> Ba> Ca> K> Na> Li. Details of experiments, tabular data and graphs are included. The author states that Antipov-Karatajev reported the rate of filtration was a function of the colloid content of the soil and the filtration velocity through soils depended upon the nature of the exchangeable ions present.

119. Lutz, J.F. The structure of soils as affecting soil erosion. Amer.Soil Survey Assoc.Bul.15:98-100, illus., processed. May 1934.
56.9 Am34 no.15

Report of fourteenth annual meeting.

Complete physical analyses were made of Davidson clay and Iredell sandy clay loam to determine structural properties enhancing or diminishing the erosiveness of soils. The reason the rate of percolation is greater for Davidson clay than for Iredell sandy clay loam is explained. The former was more highly aggregated and contained a higher percentage of aggregates that were larger than those of the Iredell and there was also a difference in the type of aggregates.

120. Mathews, O.R. Water penetration in the gumbo soils of the Belle Fourche reclamation project. U.S.Dept.Agr.Bul.447. 12pp., illus. Washington, U.S.Govt.print.off., Nov.1916. 1 Ag84B no.447

Experiments showed that water moved through the soil rather rapidly after a continued dry spell but did not permit infiltration after the soil was wet. Infiltration following dry weather was found to consist primarily of water flowing through cracks, fissures, rodent or root holes extending deep into the soil. Once a field has been covered with water little benefit to moisture penetration can result from having water continue to stand on or flow over the soil.

121. Mavis, F.T., and Wilsey, E.H. A study of the permeability of sand. Iowa Univ.Studies in Engin.Bul.7. 29pp., illus. Ames, Feb.1936.
290.9 Io93

At small hydraulic gradients the rate of flow of water through sand is inversely proportional to the absolute viscosity of the water. The permeability of Iowa river sand varied as the sixth power of the porosity and that of Ottawa sand as the fifth power. The permeability of sand varies as the square of the diameter of its grains.

122. Means,T.H. The effect of irrigation upon soil texture. Science 84(2167):39-40. July 1936. 470 Sci2

A discussion of soils,irrigated and desert,and their changes over a period of years in different map regions. Irrigation water of high salinity has been considered as a contributing factor in hastening soil disintegration. The change in the soils is apparent by the increase in clay content and the accumulation of salinity. Irrigation water penetration has been reduced by increased clay content to such an extent that in many cases it is difficult to get the soil to absorb enough water.

123. Meginnis,H.G. Influence of forest litter on surface run-off and soil erosion. Amer.Soil Survey Assoc.Bul.16:115-118,illus. 1935. 56.9 Am34 bul.16

Report of fifteenth annual meeting.

Results are given on the effect of forest litter on surface run-off and erosion applied to a severely eroded soil in northern Mississippi. Investigations have shown that the water-holding capacity of forest litter does not account for the comparatively great absorption of rainfall by litter-covered areas. Litter furnishes a habitat for worms,insects,rodents,and other biotic agents whose activities render an open porous structure to mineral soils. It also retards both the rate and depth of freezing of the soil thereby aiding in water absorption during winter rains and thaws. Description of the plots treated and the procedure used are given.

124. Metzger,W.H.,and Hide,J.C. Effect of certain crops and soil treatments on soil aggregation and the distribution of organic carbon in relation to aggregate size. Amer.Soc.Agron.Jour.30(10):833-843, illus. Oct.1938. 4 Am34P

The organic carbon contents of various size groups of soil aggregates obtained from a single soil sample were determined. Samples taken from the soil under growing corn and kafir in field and greenhouse showed as good aggregation under the sorghum crop as under corn. When oats succeeded these two crops in the field,soil samples removed from the oats stubble revealed a greater degree of dispersion where oats followed sorghum than where corn was the preceding crop. Sweet clover left the soil better aggregated after 1 year's growth than soybeans,while alfalfa and sweet clover gave similar results. Soil fallowed for 2 years in the field was less aggregated than soil fallowed for 1 year.

Limed soil supporting sweet clover and red clover in a greenhouse experiment was more highly aggregated than similar soil unlimed but supporting these crops. Unlimed and unleached fallow soil in the greenhouse was as well aggregated as limed fallow soil. It is suggested that perhaps the combined action of lime and a legume crop,or possibly other crops,produces an aggregating

force which lime alone may not exert. The grasses failed to produce the aggregation of the soil expected of them, but their failure in this experiment may have been due to the shortness of the growth period. The more aggregated portions of the soil contained significantly more organic carbon than the less aggregated portions. Ultimate particle size in the various groups of aggregates was quite similar.

125. Mitchelson, A.T. Underground storage by spreading water (abstract). Amer. Geophys. Union Trans. (1934) 15, pt. 2: 522-523.
330.9 Am3 15th, pt. 2, 1934

During 6 years of study by the Division of irrigation of the Bureau of agricultural engineering on factors considered influential in efficient water spreading particular emphasis was placed on the rate of percolation through the different prevailing soil types and formations. Other factors studied were the effect of temperature, rise and fall of ground-water on the rate of percolation, and the spreading of silty water on the efficiency of the process. Comparative rates of infiltration are given for different soil conditions over a long period. Temperature has some effect on the percolation rate but it is overshadowed by the effects of other important factors.

126. Mitchelson, A.T., and Muckel, D.C. Spreading water for storage underground. U.S. Dept. Agr. Tech. Bul. 578. 80pp., illus. Washington, U.S. Govt. print. off., Dec. 1937. 1 Ag84Te no. 578

Data are presented on spreading water for underground storage and percolation rates of various fields. Other factors being equal, the highest percolation rates are obtained on land with the native vegetation and soil covering the least disturbed. Vegetation has a beneficial effect on the percolation rate. Temperature has some effect on the rate of percolation but the change in temperature of the water during the spreading season was so small that its effect was overshadowed by other more important factors. The ground water has no marked effect on the percolation rate until it comes in actual contact with the saturated soil extending below the ground surface when a very sharp decrease takes place. Maximum percolation rates are obtained during the period the ground-water level drops after it has made contact with the ground surface, but only during the first few feet of drop.

Percolation rates in basins or ponds, with the vegetation removed, decrease with the continued application of water. This decrease is due to resorting of the soil particles and puddling of the soil surface. Higher rates of percolation in basins may be maintained by frequent harrowing or raking of the ground surface.

127. Mitscherlich,E.A. Bodenkunde für land- and forstwirte. Ed.2, 317pp.,illus. Berlin,P.Parey,1913. 56.4 M69
In German. Title: Soil studies for land and forest management. Der vegetationsfaktor wasser,pp. 113-166.
Under the title "Die Wasserleitung im Boden," (the conduction of water in soils),the effect of temperature of the soil on the movement of water into the soil is considered. With a decrease in temperature the capillary constant increases and a great increase occurs in the specific viscosity,thereby decreasing the rate of water passing through the soil. Also the various salt solutions have a distinct effect upon the velocity of flow and rise of water in the soil. Data on infiltration rates are given.

128. Morris,H.M. The insect and other invertebrate fauna of arable land at Rothamsted. Ann.Appl.Biol.9(3/4):282-305,illus. Nov.1922. 442.8 An72 v.9,1922
The investigation determined the species of insects and other invertebrates,their relative numbers,the depth at which these organisms occur,and the effect upon them by application of farmyard manure to the land. The uniformity and loose texture of the surface soil has been largely attributed to them. By means of their burrows,air and water are enabled to penetrate the soil. Garden soil was calculated to contain 53,767 earthworms and was found to contain 196,020 open burrows per acre,but in these investigations 1,010,101 were found on the manured plot and 457,912 on the control plot. The greatest number of both insects and other invertebrates occurred in the upper three inches of soil. The worms,insects,and insect larvae were beneficial in loosening the soil and facilitating aeration and drainage.

129. Moser,Frank. The influence of cropping practices on some physical and chemical properties of soil. Soil Sci.48(5):421-431. Nov.1939. 56.8 So3
Studies on the effects of various cropping systems on the erodibility of soils are presented for plats at Rigerville,Duncan,and Greer,South Carolina. The nature and extent of organic matter of a soil to the percolation rate are extremely important. Generally the run-off was high and the percolation rate was low where the humus content was low,whereas the run-off was lower and the percolation rate higher where the humus content was high. Soil porosity,as indicated by the percentage volume of macropores,also appeared to be associated with erosion losses,as large soil and water losses usually occurred on soils with the lowest porosity,and small losses occurred on soils with higher porosity. The percentage volume of macropores as shown for the various cropping systems indicated that soils well supplied with organic matter had the greatest effective porosity.

130. Muckel, D. C. Some factors affecting the rate of percolation on water-spreading areas. Amer. Geophys. Union Trans. (1936) 17,pt.2:471-474. 330.9 Am3 17th, pt.2,1936

Three plots, 0.38 acre each, on a debris-cone were arranged for constant flooding and provided with equipment for measurement of run-off. One plot was in vegetation and the other two were fallow. Sufficient water was added to insure 100 percent coverage at all times for a period of 87 days and later two of the plots were flooded for 105 days. The rate of percolation on the plot containing vegetation was consistently higher, being approximately 300 percent higher than that of the cultivated plot. The all-time average rate of percolation of the vegetated plot was 5.5 acre-feet per day and on the denuded plot 3.84 acre-feet per day. Temperature recordings were made and data showed temperature had slight influence on the percolation in cases where the temperature varied a few degrees.

131. Munns, Edward. Particulars regarding experimental forests and work-centers for hydrologic research. Amer.Geophys. Union Trans.(1939) 20,pt.4:540-541. 330.9 Am3 20th, pt.4,1939

This article consists of Appendix A-1, the report of the committee on run-off, 1938-39,W.G.Hoyt, chairman. Experiments are conducted on infiltration-capacity at Gale river experimental forest, Coos county, N. H.,and on infiltration-moisture by plot-studies at Holly Springs work-center, Marshall county, Miss. Lysimeter-studies of infiltration are also conducted at LaCrosse work-center, LaCrosse county,Wis.; Manitou experimental area, Teller county, Colo.;Boise Basin branch station, Boise county, Idaho; Parker creek experimental forest,Gila county, Ariz.;San Dimas experimental forest,Los Angeles county,Calif.; and at Northfork work-center, Madera county, Calif.

132. Munns,E.N.,Preston,J.F.,and Sims,I.H. Forests for erosion control. U.S.Dept.Agr.Yearbook 1938 (Soils and Men):609-614. 1Ag84Y 1938

The part that forest cover and forest litter plays in promoting infiltration is fully described. The protection of porosity by forest litter, the effect of decomposition of litter upon the improvement of porosity through its function in the formation of granular or crumb structure, and the effect of the decomposition of roots upon the formation of ducts for conveyance of water to sub-surface levels are discussed.

133. Müntz,A.,Faure,L.,and Lainé,E. Etudes sur la permeabilite des terres faites en vue de l'arrosage. France Min.de l'Agr.Dir.Gén.Eaux et Forets,Ann.Forets-Hydraul.33:45-96,illus. 1905. 55.9 F84

In French, Title: Studies of the permeability of soils in relation to irrigation.

Permeability tests were made on soil in situ by the cylinder method and by a soil block method. These are described. Numerous tables of data on permeability (infiltration) measurements are included.

134. Müntz,A.,Faure,L.and Lainé,E. Rapports entre la constitution physique des terres et la distribution des eaux d'arrosage. France Min.de l'Agr.Dir.Gen.Eaux et Forêts.Ann.Forêts-Hydraul. 36:121-223,illus. 1907. 55.9 F84

In French. Title: Relations between physical constitution of soils and the distribution of irrigation waters.

Studies by the authors were continued. Work was started in 1902 and consists of a study of the factors of soils which apparently affect the rate of intake of water from irrigation. Permeability, the controlling factor, was measured by means of a steel cylinder 25 cm.long and 112 mm. diameter forced into the soil to a depth of 6 cm. Water was added from an inverted graduated bottle and maintained at a constant level of 3 cm. above the soil. The rate of percolation through the soil was evident from the differences in water heights measured by the graduated scale of the flask.

Abstract in English appears in Expt.Sta.Rec.24:522-523,illus. 1911.

135. Müntz,A.,and Lainé,E. Des quantites d'eau et de la frequance des arrosages suivant les proprietes des terres. France Min.de l'Agr.Dir.Gen.Eaux et Forêts,Ann.Forêts-Hydraul,44:1-130,illus. 1912. 55.9 F84

In French. Title: The quantity of water and frequency of irrigation as related to the physical properties of soils.

Studies by the authors were continued. Experiments were made to determine the amounts of water most favorable to crops when applied at equal intervals and the influence on yield by the application of equal quantities of water at irregular intervals. The results show that there is ordinarily a decided waste of water.

The following is taken from an abstract in Expt.Sta.Rec.32(1915): 586-587 with the title, "Relations between physical constitution of soils and the distribution of irrigation waters."

The continuation of this study includes the module, and the time, method, and amount of irrigation most favorable to crops, in their experimentation. The permeability of the soils tested varied from an infiltration rate of 0.5 to 60 cm.(.2 to 23.4 in.) per hour. The quantity of water computed on the basis of continual flow for these soils during the growing season of the crop varied from 0.23 to 0.85 liters per second per hectare according to the physical properties of the soil.

136. Murphy,H.F. The organic matter content and moisture relations of some cropped and virgin soils. Okla.Acad.Sci.Proc.(1936)16:36-37. 500 Ok42 16th, 1936.

Soil samples, paired for virgin and cropped soils, were taken from four sections of the state of Oklahoma and compared for organic matter content and water-holding capacity. Cropping apparently reduced the organic matter content 18 to 35 percent and the water-holding capacity was lessened considerably. Organic matter tends to produce a suitable surface structure for water entrance as well as increasing the absorptive capacity of the soil. Data are included.

137. Musgrave,G.W. A device for measuring precipitation waters lost from the soil as surface run-off, percolation, evaporation and transpiration. Soil Sci.40(5):391-401,illus. Nov.1935 56.8 So3

A complete description of lysimeters with details of construction, drawings and photographs is given. Measurements of percolation are made from soil columns of undisturbed structure in lysimeters. A table illustrates the distribution of water from one year's rainfall. Data from this type of lysimeter may be used for studies of infiltration.

138. Musgrave,G.W. The infiltration capacity of soils in relation to the control of surface run-off and erosion. Amer.Soc.Agron.Jour.27 (5):336-345,illus. May 1935. 4 Am34P

An experimental procedure is developed determining minimum as well as maximum rates of infiltration of water into soils in situ. Especially designed equipment was used for the experiments. Metal cylinders were forced into the soil and water was applied at a uniform depth on the soil surface. Marshall and Shelby silt loam soils were tested. Graphs illustrate the effects of infiltration from a heavy rainfall. Detailed descriptions of the equipment and procedure, photogrphs of the installations,graphic illustrations, and data of the tests are given.

139. Musgrave,G.W. Notes on recent developments in the infiltration problem. U. S. Soil Conserv. Serv. Soil Conserv.5(9):232-234. Mar.1940. 1.6 So35

Comparison of infiltration rates of soils is made between a well-managed soil and a poorly managed soil. Measurements of some physical characteristics of each soil are given as well as photographs illustrating the porosity of the soil. Graphs for Vernon fine sandy loam from abandoned land and virgin, pastured land illustrate comparative run-off and infiltration rates. The steps of a cycle of an uncontrolled system may be as follows: (1) Low infiltration followed by poor vegetal cover; (2) poor vegetal cover followed by high amounts of surface run-off; (3) high run-off followed by loss of aggregated and more porous portion of the surface; (4) loss of porous portion followed by lower infiltration.

140. Musgrave,G.W. A quantitative study of certain factors affecting soil losses as the logical basis for developing practical method of erosion control. Amer.Geophys.Union Trans.(1934) 15,pt.2:515-521. 330.9 Am3 15th,pt.2,1934

Study of the infiltration capacity of Marshall silt loam was made under numerous conditions on normal soil. Data were obtained from lysimeters and from small plots. The effect of additions of organic matter to the soil was investigated. Infiltration-capacity may be increased by incorporation of organic matter and by attention to the character and condition of the vegetative cover. Several tables of data are presented.

141. Musgrave,G.W. The significance of field structure in the water relations of soils. Amer.Soil Survey Assoc.Bul.17:155-162,illus. May 1936. 56.9 Am3 no.17

Paper given at the sixteenth annual meeting.

Infiltration rates and percent porosity of soil surface cultivated 0 inch, 4 inches, and 6 inches deep were determined. Studies are reported of the effect upon the porosity and rates of infiltration by incorporation of organic matter in the form of manure in fallow soil and soil for raising corn. The data from these experiments were obtained from lysimeters containing Marshall or Shelby silt loams. The greatest significance resulting from these tests lies in the fact that modifications of the structure of the soil in the surface 6 inches are manifested in the movement of water to a depth of at least 3 feet. Tabular data and graphs are included.

142. Musgrave,G.W. Some relationships between slope-length, surface-runoff, and the silt-load of surface-runoff. Amer.Geophys.Union Trans. (1935)16,pt.2:472-478. 330.9 Am3 16th,pt.2,1935

The effects on run-off and silt-load by high-intensity and low-intensity rains from different slope lengths of Marshall silt loam were studied. Data are given as well as graphs showing the relation of infiltration, run-off, and silt-load to slope-length. A greater percentage of run-off occurs from short slopes than from long slopes for low-intensity rains but the reverse occurs for high-intensity rains. This is accounted for by the infiltration rate and the relative areas of the two slopes.

143. Musgrave,G.W.,and Free,G.R. Preliminary report on a determination of comparative infiltration rates on some major soil types. Amer.Geophys.Union Trans.(1937)18,pt.2:345-349,illus. 330.9 Am3 18th,pt.2,1937.

Infiltration rates for Marshall and Shelby silt loams and for eight soils occurring as outstanding soils in the state of Georgia are reported. Rates were determined by Musgrave's method using an initial 3-hour period followed by a similar period. A discussion of results is included.

144. Musgrave, G.W., and Free, G.R. Some factors which modify the rate and total amount of infiltration of field soils. Amer.Soc.Agron.Jour. 28(9):727-739. Sept.1936. 4Am34P

Galvanized cylinders 6 inches in diameter and 14 to 18 inches in length were forced into the soil in situ and measured quantities of water added to determine infiltration rates. At conclusion of first part of experiment some of the cylinders were removed and others were left undisturbed for a comparative experiment. A perforated sheet metal disk placed over the surface of the soil insured equalization of water distribution. Details of methods and results in form of tables and graphs are given. Many measurements of the rates of infiltration of Shelby and Marshall silt loam soils were made to study the effect on infiltration by such factors as porosity, soil moisture, and vegetal cover.

145. Musgrave, G.W., and Neal, O.R. Rainfall and relative losses in various forms. Amer.Geophys.Union Trans. (1937)18, pt.2:349-355, illus. 330.9 Am.3 18th, pt.2, 1937

Run-off and percolate from lysimeters of Marshall silt loam untreated and others treated with organic matter annually, both in a cropped condition and in fallow, were measured for the period 1933-36. Tabulated data and graphs are given. Similar measurements from lysimeters of Shelby silt loam treated and untreated in fallow condition were made annually for the period 1934-36. Since all lysimeters receive the same rainfall and have the same area and surface slope, the differences in infiltration for the various soil treatments are apparent from the tabulated data.

146. Musgrave, G.W., and Norton, R.A. Soil and water conservation investigations at the soil conservation experiment station, Missouri valley loess region, Clarinda, Iowa. U. S. Dept.Agr.Tech.Bul.558, 181pp., illus. Washington, U. S. Govt.print.off., Feb.1937. 1 Ag84Te no. 558

Rates of infiltration for Marshall and Shelby silt loams, pp.56-60. The effect of treatment of soil and cropping on relative infiltration from lysimeters and the indirect measurement of infiltration rates from a comparison of rainfall intensity and run-off from control plots are discussed. Surface impoundage and the relation of soil infiltration-capacity to the practical value of surface-impounding treatments are considered with supporting data. Individual plot records of run-off and erosion, and similar records for lysimeters including monthly percolation rates, are found in the appendix.

147. Neal, J. H. The effect of the degree of slope and rainfall characteristics on run-off and soil erosion. Mo.Agr.Expt.Sta.Res.Bul.280, 46 pp. Columbia, Apr.1938. 100 M693 no. 280

Simulated rainfall experiments on Putnam silt loam to determine run-off, erosion and infiltration measurements were made for slopes ranging from 0 to 16 percent; for rainfall intensities ranging from 0.9 to 4.0 inches per hour; for rain duration ranging up to 6 hours; and for different initial moisture contents and surface conditions of the soil. Infiltration rates resulting from natural

rainfall are contrasted with those from other methods of determination. Photographs and detailed descriptions are given of the equipment. The results are indicated by data and graphic illustrations.

148. Neal,J.H. Effect of degree of slope and rainfall characteristics on run-off and soil erosion. Agr.Engin.19(5):213-217,illus. May 1938. 58.8 Ag83

Also appears in Soil Sci.Soc.Amer.Proc.(1937)2:525-532,illus.

The rate of infiltration was determined in two ways: by applying water to cylinders forced into the soil, and by the difference between rainfall and run-off measured from a plot subjected to a measured quantity of artificial rainfall. Description of the latter apparatus is included. The results obtained from measurements of artificial rainfall,run-off,and amount of erosion are given in form of graphs. Infiltration was not affected by either the slope or the rainfall intensity, but varied inversely as the initial soil moisture content.

149. Neal,J. H. Moisture relationships of soils in situ. Agr.Engin.13(5): 128-132. May 1932. 58.8 Ag83

Factors prominent in the role of soil characteristics which affect infiltration and its rate are discussed. Such characteristics are pore space,contraction of soils on drying,amounts of water required to bring soil to different stages of moistness,density,etc. Data are included as tables and graphs.

150. Neal,O. R. Soil moisture content under various conservation practices. Amer.Geophys.Union Trans.(1939)20,pt.4:686-690,illus. 330.9 Am3 20th,pt.4,1939

Marshall silt loam is characterized by a fairly rapid rate of infiltration. The rate and amount of infiltration of water by force of gravity is largely dependent on the non-capillary porosity of the various layers in the soil profile. The rapid distribution of moisture under field conditions on Marshall silt loam has been repeatedly observed and occurs in accordance with the above. This article consists largely of soil moisture investigations.

151. Neal,O.R.,Richards,L.A.,and Russell,M.B. Observations on moisture conditions in lysimeters. Soil Sci.Soc.Amer.Proc.(1937)2:35-44, illus. 56.9 So3 2d,1937

Tensiometers were placed at depths of 4,8,21,and 34 inches in a lysimeter of fallow soil (Marshall silt loam) to which heavy applications of manure had been made annually. Readings were made at least daily. Tensiometers were also placed at a depth of 21 inches in a lysimeter cropped to corn which had organic matter added similar to above annual application and in a lysimeter fallow without organic matter treatments. Infiltration and percolation data for lysimeters are given and shown graphically.

152. Nebolsine, Ross. Artificial methods of groundwater recharge. In Upstream Engineering Conference, Washington, D. C.,1936. Headwaters control and use, pp.187-188,processed. Washington, U. S. Govt. print.off.,1937. 1 Ag84H

A discussion of factors affecting infiltration such as a horizontal impervious clay stratum several feet below a horizon of soil ideal for infiltration. The deposition of sands and gravels offers great resistance to infiltration if there is horizontal stratification or settling of sand particles down through the water on their flat sides. Examples are cited to such formations in nature.

153. Parker,P.A.M. The control of water as applied to irrigation, power and town water supply purposes. 1055pp.,illus. New York,D.Van Nostrand co.,1913. 290 P22

Percolation of water through sand and gravel,pp.24-28.

The passage of water through a layer of sand or fine gravel is effected by capillary flow through the small irregular tubes that are formed by the void spaces in the sand. The author found it necessary to consider the laws of capillary flow and carried out a mathematical treatise on it. Experiments were made with clear water excepting a set to show the effect of a small quantity of clayey or dirty water in diminishing percolation. Data showing the effective size of the sand grains in millimeters for determining velocity of percolation are given in tabular form.

154. Pearse,C.K. A simple device for measuring the absorption rates of soils. Science 85(2):459-460,illus. May 7,1937. 470 Sci.2

A small portable apparatus for applying a thin sheet of water to a small enclosed undisturbed soil surface is described. Provision was made for collection and measurement of run-off from the small plot. The apparatus is illustrated.

155. Pearse,C.K. Specifications for the construction and operation of a portable apparatus for measuring surficial run-off and erosion. 27 numb.l.,XII plates,illus.,mimeogr. Ogden,Utah,U.S.Intermountain forest and range expt.sta.,1936. 1.9 F76232Sp.

The portable apparatus for measuring run-off from a small plot and the rainfall simulator for applying water to the plot at predetermined rates are described in detail. Drawings with specifications of the more fundamental parts and photographs of the set-up are included. Although no reference is made to infiltration, a complete description is given of the rainfall-simulator small-plot apparatus used for measuring infiltration rates.

156. Pearse, C.K., and Bertelson, F.D. The construction and operation of an apparatus for the measurement of absorption of surface water by soils. 10pp., illus. Ogden, Utah, U.S. Intermountain forest and range expt. sta., 1937. 1.9 F76232C

An apparatus and a procedure were developed for spreading a thin film of water at a constant rate over 1 sq.ft. of soil in situ and measuring the rate of run-off. Rate of absorption is determined as the difference between the rate of application and rate of run-off. Detailed drawings and illustrations of the equipment are given. The apparatus is small enough for conveyance by one person from one location to another.

157. Pearse, C.K., and Woolley, S.B. The influence of range plant cover on the rate of absorption of surface water by soils. Jour. Forestry 34(19):844-847, illus. Sept. 1936. 99.8 F768

Special equipment was used to measure surface run-off on 40 one-foot square bare plots and 40 plots of same size with single type vegetation. Twelve of these had plants with fibrous root systems and twenty-eight had plants with the typical tap-root systems. Apparatus used is illustrated. Details and results are given. Absorption rates are given for water applied at known rate. Cross-section cut through plot at the completion of each test was made to determine depth of penetration of moisture into the soil.

158. Peele, T.C. The effect of lime and organic matter on the erodibility of Cecil clay. Soil Sci. Soc. Amer. Proc. (1937)2:79-84. 56.9 So3 v.2, 1937

Data show additional calcium carbonate applied with or without organic matter to Cecil clay decreases the permeability as indicated by the percolation rates. Addition of calcium carbonate caused an increase in the percentage of small aggregates, particularly those having diameters between 0.01 and 0.02 mm. Some unaccounted-for effect on percolation rates was apparent from organic matter additions to the soil.

159. Peele, T.C., Beale, O.W., and Latham E.E. The effect of lime and organic matter on the erodibility of Cecil clay. Soil Sci. Soc. Amer. Proc. (1938)3:289-295. 56.9 So3 v.3, 1938

Experiments were performed on plots of 1/1000 acre of Cecil clay. The soil was limed and hay was added to portions and incorporated as organic matter. Results indicated that the addition of organic matter to Cecil clay resulted in a slight increase in organic matter content of the soil after an interval of six months and the increase in porosity was practically negligible. Permeability of the clay was decidedly reduced by lime applications as measured by the percolation rates, but not significantly affected by the

organic-matter applications. The reduced permeability of Cecil clay following applications of lime is probably due to the clogging up of pores by the increased amount of small aggregates (below 0.02 mm. in size) resulting from the dispersing effect on the large water-stable granules. Data and illustrations are included.

160. Post,W.S. Santa Ana investigation. Flood control and conservation. Calif.Dept.Pub.Works Div.Water Res.Bul.19. 357pp.,illus. Sacramento,1929.

Disposal of rainfall,pp.152-157, and Absorption of water by gravel, existing spreading works,pp.165-179.

The chapter on disposal of rainfall was prepared by H. F. Blaney.

Data in tabular form of rainfall penetration for two annual periods during 1926 to 1928 are given with an estimate of mean penetration values within valley floor in acre-feet per square mile for varying rainfall. Table of data is given for rates of absorption in terms of second-feet per acre and depth of water in 24 hrs. for the various areas described. Photographs show spreading dams with adjacent areas,settling basins, and other diversion dams.

161. Powers,W.L. Soil-water movement as affected by confined air. Jour. Agr.Res.49(12):1125-1133. Dec.1934 1 Ag84J

Measurements were made to determine the effect of confined air on the movement of water downward into the soil. Details of methods and descriptions of apparatus are given for laboratory experiments on Chehalis loam and Willamette silty clay loam in special tubes 3x40 cm. The effects of different air pressures were studied and graphs show their effect on the percolation rate.

162. Powers, W. L. A study of the colloidal fraction of certain soils having restricted drainage. Internatl. Cong.Soil Sci.,Washington,D.C.Second Comm.Proc.and Papers(1927)1st v.2:508-511. 56.09 In84P 1st v.2,1927

The movement of water in soils is determined by a combination of many factors among which the resistance offered by the soil and influenced by amount,composition,and state of colloids present is of chief importance. Dayton and Vale soils were treated with various flocculents and the maximum rate of percolation determined. The greatest increase in rate of percolation came from treatments of lime and manure,sulphur and manure,green manure,alum,and a saturated solution of calcium sulphate. With distilled water, the rate decreased with the time leached, which was probably due to swelling and removal of electrolytes. Air drying largely restored permeability.

163. Puri,A.N. A new percolating cylinder and some of its uses. Agr. Jour.India 24(6):408-412. Nov.1929. 22 Ag83

A detailed description of the cylinder and the procedure used in the tests are given. By adding lime to Dacca soil (a highly acid soil which would neither support vegetation or retain water but a very short time) the rate of percolation decreased with increasing amounts of lime. To alkali soils which would not bear crops and to those that would bear crops well, the addition of gypsum of rates in excess of 0.06gm./100gm. soil caused an increase in the rate of percolation. Data are given on percolation rates for a variety of soils and treatments.

164. Ramser,C.E. Run-off from small agricultural areas. Jour.Agr.Res. 34(9):797-823,illus. May 1927. 1 Ag84J

Numerous measurements in inches per hour of rainfall and maximum run-off are given for areas of 1.25 to 112 acres. The value F (sometimes considered infiltration) can readily be obtained from the difference between the value for "the average rate of rainfall during the time of concentration" and "the maximum rate of run-off" which are given in inches per hour. This is an extensive article on the subject with numerous illustrations,graphs,and tables of data.

165. Riesbol,H.S.,and Sherman,G.L. Watercycle lysimeters for watershed studies. Agr.Engin.19(3)123-128,illus. Mar.1938. 58.8 Ag83

Lysimeters of the weighing type are installed to provide means of determining the rate of infiltration,deep percolation,evapotranspiration,and soil moisture. The design and construction of these lysimeters and of the weighing device are given in detail. The plan and typical cross-section of the battery of watercycle lysimeters and a schematic diagram are illustrated.

166. Robertson,J.H. A quantitative study of true-prairie vegetation after three years of extreme drought. Ecol.Monog.9(4)432-492,illus. Oct.1939. 410 Ec72

The apparatus described and illustrated for making infiltration determinations in steel cylinders with applications of 1 inch of water. Curves show rates of infiltration for soil at Jamaica,Crete, Carleton,Clay Center and Nelson,Nebraska, and at Belleville and Montrose,Kansas,with a cover comprised of one of the following: a vegetative cover of aster,big bluestem,prairie dropseed,dead crowns,prairie rose, western wheat grass,slough grass,buffalo grass, blazing star, blue grama, lead plant, side-oats grama, sand dropseed, little bluestem,or downy brome, or a deposit of one-year old alluvial or 2 inches of dust. The rates are those obtained from initial application of 1 to 4 inches of water. The article primarily concerns abundance of plant life, trends of change in floristic composition in permanent plots, and available soil moisture, but short discussions of the infiltration rates are included with the infiltration curves for each of the districts.

167. Roessel,B. Doorlalendheidsbedalingen. Tectona 31(8):521-538, illus. Aug.1938. 99.8 B65

In Dutch.Title:Infiltration determinations.

Summary in English,Measurements of infiltration rates,pp.537-538.

The author reviews the works of other investigators on infiltration rates of water into the soil. In order to compare different soils, the infiltration rates must have been continued until they became constant. The rates obtained from lysimeters are lower than those determined from run-off trials possibly due to a capillary fringe in the lysimeter causing decreased permeability. Data and graphs of other investigators on infiltration rates are included. A method is presented for determining infiltration by measuring the difference in run-off from a pan provided with an outlet tube set at the surface level of the soil and from a similar bottomless pan forced to a depth of 1 cm. provided with a tube for run-off from the surface of the soil. Both pans are submerged by a layer of sand to eliminate the factor of evaporation. Rainfall is measured by a rain gauge. The difference between the amount of run-off from the pan and the bottomless pan is equal to the infiltration of the soil areas encompassed by the pan.

168. Rogers,W.S. Soil factors in relation to root growth. Internatl. Cong.Soil Sci.First Comn.,Oxford,Eng.Trans.(1935)3,v.1:249-253. 56.09 In843 v.1,1935

Root systems and their growth were studied at East Malling research station,Kent,Eng. Results obtained from observation of rainfall and from application of irrigation water to dry soil supported the theory that a given portion of soil must be wetted to its field capacity before it allows an appreciable amount of water to pass on to other portions of the soil.

169. Rowe, P. B. The construction, operation, and use of the North Fork infiltrometer. U. S. Forest and Range Expt.Sta.Calif.,Berkeley, Calif.Misc.Pub.1. 64pp.,illus. /Oakland/ Feb.1940. 1 F7626M no.1

Also Flood control coordinating com.misc.bul.no.1.

In addition to a complete description with illustrations of the equipment for rainfall-simulator tests, there is considerable discussion with data on sampling procedure and determination of sampling error. The recording and interpreting of field observations and records are considered in detail with a sample record given. The interpretation and analysis of the infiltration data are accomplished by means of a series of curves based on data from actual field runs. The value of infiltration data collected depends upon the adequacy and accuracy of the instrumentation, the completeness and reliability of recorded field data and observations, and the operator's accuracy and operating technique and his knowledge of the fundamental principles of infiltration and the factors influencing it.

170. Rowe, P. B., Ilch, D.M., and Bollaert, R. An infiltration study of a denuded and a forest covered soil. U. S. Dept. Agr. Calif. Forest and Range Expt. Sta. Res. Note 14. 4pp., illus. Berkeley, Calif., Jan. 1937. 1.9 F7626R no. 14

Infiltration was determined on a denuded soil and an adjacent forested soil by a modification of the Auten tube method. Brass cylinders 2 by 12 inches were placed in soil in situ to a depth of 3 cm. and water was maintained at a constant depth during the test. The water absorbed was measured at 5-minute intervals. A comparison of the rates at which water was absorbed gives an empirical measure of the infiltration capacity. Tests averaged approximately 20 minutes for each individual run. Rates decreased rapidly during first 15 minutes but became more or less constant during the following 10 minutes. Data and discussion are included.

171. Russell, E.W. Soil structure. Imp. Bur. Soil Sci. Tech. Commun. 37, 40pp. London, 1938. 56.9 Im72 no. 37

This is a treatise of the subject with a bibliography but without tabular data and illustrations. Some of the principal topics considered are: (1) Permeability methods, specification of soil pore-space, aggregate analysis, and structural coefficient of a soil relative to soil structure; (2) Classification of soil structure and aggregates; (3) Methods of controlling the structure of the soil through such agents as cultivation, climate, fertilizers and growing crops; (4) Crumb formation described by the flocculation theory and through types of cementation present in the soil by such agents as clay, iron hydroxide and organic matter with their relative importance as cements and the interactions between them; (5) Application of soil structural analysis to agricultural practice.

172. Santa Maria valley water conservation district. Economic and engineering phases of flood control, water and soil conservation, and protection of watershed in southern California. 198 numb. l., illus., mineogr. Santa Maria, Calif., Aug. 1939. 290 Sa53

The importance of valley lands in a flood control program, pp, 17-26, by J. E. Johnston. In reference to natural storage of water underground, most infiltration of distributed run-off water from uphill areas takes place on the border lands between the hills and the valley floors. The possibilities of not only absorbing the direct rainfall but also nearly all the run-off from the foothill areas except the concentrated channel flow of high run-off are considered. Data from the Soil conservation service are given to illustrate the differences in run-off from clean-tilled soil and other types of cropping. Methods of increasing infiltration, such as creating an artificial impedance to the flow of run-off to permit longer time for the water to sink in, are contour

cultivation, basin listing, terracing, etc. With appropriate crops, for example, lima beans, it is possible to open passages into the under-soil by plowing or subsoiling prior to the rainy season. Application of mulch delays run-off and increases infiltration.

The practical features of flood control on the valley lands, pp.27-37, by W. C. Barrett. Considering methods of flood control in mountainous areas, the value of natural forest litter as a means of increasing infiltration has been proved beyond question by experience and experiment. The protection against fire which would cause the removal of the forest litter is stressed.

Calculation of flood flows, pp.38-53, by M. F. Burke. Absorptive soil that has become an impermeable area through introduction of cities, highways, etc., amounts to approximately 58 percent for apartment house districts, and 95 percent for heavy commercial districts. The changing of absorptive areas to impermeable ones increases the flood potentialities for the drainage area. The effects on infiltration by frozen soil and by raising the water table to ground level are considered. The use of the unit-hydrograph method originated by L. K. Sherman and amplified by M. M. Bernard, and factors of infiltration are discussed. A general description is given of tests made by sprinkling water at known rates on a plot and measuring the resultant rate of run-off.

Water spreading for conservation of excess run-off - - - a California practice, pp.114-121, by A. T. Mitchelson and D.C. Muckel; Water spreading, pp.122-130, by D. C. Muckel. Water spreading requires a system which will permit the greatest amount of water to percolate in a given time from a given area. In the basin method experiments and observations show persolation rates decrease as the process continues. The submerged ground surface tends to puddle and seal off the percolating area, which is remedied by harrowing or scraping. No particular advantage over harrowing was gained by removing the topsoil from the basins. The ideal method is to pass the water in a thin sheet and at slow velocity over the land surface. The highest percolation rates are obtained on areas where the native vegetation and soil covering have been least disturbed.

The effect of vegetation on watersheds, pp.148-155, by E.C.Kenyon, Jr. Vegetative cover on the slopes constitute an important factor in control of floods by increasing percolation. When soil is exposed to rainfall, soil particles are carried into the numerous minute openings in the soil surface. As little as 2 percent of silt (by weight) in water causes percolation rates to drop to about one-tenth of rate of clear water. Roots also increase percolation by providing a more porous soil condition through their action in breaking up and disintegrating the underlying soils and rock. Experiments by Lowdermilk at Berkeley proved that plots having a brush cover compared to burned-off plots had a run-off relation of 1 to 3.7 and that the finer textured the soil, the more effective litter became in checking surface run-off.

173. Scofield,C.S. The movement of water in irrigated soils. Jour. Agr.Res.27(9):617-693,illus. Mar.1924. 1 Ag84J

The rate of penetration of irrigation water into the soil was determined by adding water to various dry pulverized soils in glass tubes. Rates for periods extending from 1 hour's time to 14 months are reported. Factors influencing the rate of percolation are discussed. Soil solutions were studied,also the effect of dilution. The rate of penetration of water into a dry soil is influenced not only by the general texture of the soil but even more by the physical reactions of the soil material to water. The physical condition of the soil,which influences so profoundly the movement of water through it,is largely the result of chemical reactions that take place between the soil particles and the salts dissolved in the soil solution. The physical condition of the soil and particularly its permeability to water is largely influenced by the character of the bases that are combined with the soil. When the alkaline bases,sodium and potassium,predominate the soil is deflocculated and impermeable. When the earthy bases,calcium and magnesium,are in excess the soil is flocculated and permeable. Tabular data,graphs,and illustrations are included.

174. Shaw,C.F. The normal moisture capacity of soils. Soil Sci.23(4): 303-317. Apr.1927. 56.8 So3

In deep uniform soil any water added by rain or irrigation penetrates the soil rapidly and soon approaches the normal moisture-capacity state of distribution. The flow of water downward through the soil mass is the result of two forces,gravity and inverted "capillary movement" or film force. As the water moves downward a part is absorbed by the colloidal material present and an additional amount is held as thin films surrounding the soil grains with thicker waist-like accumulations where the soil grains touch each other. Moisture determinations were made on the soil at various depths for different lengths of period after an irrigation that saturated the upper horizon of the soil. Many tables of data and graphical illustrations on the movement of water downward through the soil are given.

175. Sherman,L.K. Determination of infiltration-rates from surface-runoff. Amer.Geophys.Union Trans.(1938)19,pt.1:430-435,illus. 330.9 Am3 19th,pt.1,1938

Infiltration-rates occurring only during rain-intensities producing surface-runoff are determined from two sprinkler-experiment runs made by the Soil conservation Service at Lincoln, Nebr. Descriptions of the plot and the experiments,data collected, and hydrographs of the test-runs are included. Two formulas are used in computations and comparisons are made between them. Appended to the article are the development of a formula for infiltration-rates and a discussion by H.R.Leach of the author's method for determining infiltration-rates.

176. Sherman,L.K. The Horton method for determination of infiltration-rates. Amer.Geophys.Union Trans.(1936)17,pt.2:312-314,illus. 330.9 Am3 17th,pt.2,1936

By using a hydrograph of surface run-off and application of Bernard's pluviograph,it is possible to determine infiltration during the storm-period on a drainage-basin,provided good records of rainfall and of stream-flow are available. The derivation of infiltration is illustrated by an example. After giving data on five cases the author concludes that the middle period alone is applicable for the measurement of infiltration-rates.

177. Sherman,L.K.,Bernard,M.M.,and others. Discussion of paper 1898, An approach to determine stream flow. Amer.Soc.Civ.Engin. Trans.(1935)100:365-395,illus. 290.9 Am3 100th,1935

Also in Amer.Soc.Civ.Engin.Proc.v.61,pt.2,no.8,Oct.1935.

Paper 1898 was presented by M.M.Bernard. The foregoing named persons contributed to the portion of the discussion relating to infiltration.

Two hydrographs,one with high rainfall-intensity and the other with low rainfall-intensity,based on the same duration of rainfalls on the same hypothetical drainage basin are presented. Infiltration rates are given. The most accurate procedure of estimating infiltration probably will not be based on utilizing a coefficient of retention or run-off but will be deducted from data on the storm similar to that presented by M.M.Bernard,bearing in mind,however,that infiltration is greatest at the beginning of the storm and practically ceases when surface run-off has reached the main stream. The pluviograph is a hydrograph of run-off if or when the surface of the drainage basin is impervious. Under varying rates of infiltration it is very useful in a study of maximum rates of run-off due to a storm. It is not a graph of run-off plus infiltration since the distribution of the infiltration loss throughout the period of run-off is in proportion to run-off. Tabular data and graphs are included.

178. Shreve,Forest. Rainfall,run-off and soil moisture under desert conditions. Assoc.Amer.Geog.Ann.24(3):131-156. Sept.1934. 500 As73

A device similar to a lysimeter was installed on "adobe" soil, a fine textured dark gray alluvial clay free of stones having a waterholding capacity of 50.4 percent. The soil was encased in situ. The device makes it possible to measure run-off from a small area and/or any water penetrating the upper layers of the soil. A full description and a sketch of the apparatus are given. Data on rainfall and its intensities comprise a large part of the article.

179. Slater,C.S.,and Byers,H.G. A laboratory study of the field percolation rates of soils. U.S.Dept.Agr.Tech.Bul.232 23 pp., illus. Washington, U.S.Govt.print.off. Jan.1931. 1 Ag84T no.232

Percolation rates were determined on soil cores from the field and on similar disturbed samples of soil. The cause of variation in percolation rates between laboratory-packed samples and field cores of the same soil was studied. Suspension percent and percolation ratio are valuable criteria of relative field permeability. The field-percolation rate of soil is governed more by the water passageways it contains (root channels or structural cleavage) than it is by the character or volume of the pore space of the soil mass. The percolation rates of cores serve as a means of studying field permeability,but these rates vary too widely for cores of the same soil to attempt to fix field-percolation rates by this means alone unless obtained from a large number of cores.

180. Slichter,C.S. Theoretical investigation of the motion of ground waters. U.S.Geol.Survey Ann.Rpt.(1897/98)19,pt.2:300-384,illus. 1899. 407 G29R 19th,pt.2,1897/98

Motion of ground water in vertical planes, pp.350-357.

A mathematical analysis of ground water movement in vertical planes is given. A formula for vertical movement of water through permeable material is included and its use is illustrated by the solution of a practical problem.

181. Smith,F.B.,Brown,P.E.,and Russell,J.A. The effect of organic matter on the infiltration capacity of Clarion loam. Amer.Soc.Agron. Jour.29(7):521-525. July 1937. 4 Am34P

Infiltration measurements were made (similar to method used by Musgrave) with 6-inch seamless steel tubing, 14 inches in length, forced into the soil to 12 inches depth. Both field and laboratory tests were made on manured and unmanured Clarion loam. The laboratory samples were procured in the same manner as the field-test samples except that the cylinder of soil was removed to the laboratory. Organic matter increased the infiltration rate of the soil. Details of experimental procedure,graphical illustrations and data are given.

182. Smith,R.S. Experiments with subsoiling,deep tilling,and subsoil dynamiting. Ill.Agr.Expt.Sta.Bul.25:155-170,illus. Urbana, Feb.1925. 100 I16S no.258

Field experiments described were conducted on soils subjected to subsoiling,deep tillage,or subsoil dynamiting. Data are submitted to support conclusions given in the discussion. Plowing does not increase the water-holding capacity of the soil,even in arid regions; it does,however,increase the power of the soil to absorb rainfall. Tight clay subsoils,factors often causing the top soil to remain saturated during the spring,were not made previous by dynamiting. Dynamiting formed perfect basins with highly compacted walls which were entirely impervious to water. Soil moisture determinations made during two seasons on variously tilled plots show that none of the tillage treatments used increased the downward movement of moisture through the soil.

183. Smith,W.E. Modification of the index-area principle and the anticipated application of the principle to Muskingum river flood-control. Amer.Geophys.Union Trans.(1938)19,pt.1:455-460,illus. 330.9 Am3 19th,pt.1,1938

The author considers the principle of various methods and the factors involved for prediction of surface-run-off quantities from rainfall. In the sample given for Home creek watershed run-off occurs before the intensity of precipitation has reached infiltration-capacity as determined under conditions of considerable rainfall-excess. As intensity increases infiltration-rate increases, run-off occurring at both intensities. The explanation is that the ground becomes more absorptive as it becomes moist or infiltration-capacity increases somewhat with intensity because of lack of coverage by the drops of rain under lower intensities. It may be due to lack of uniformity of infiltration-capacity or rate over the whole area. A discussion follows with an example given.

184. Snyder,F.F. Hydrologic studies. In Pennsylvania Dept.forests and waters. Water and power resources board.Report of cooperative hydrologic investigations.pp.50-153,illus.,mimeogr. [Harrisburg],Aug.1939

In cooperation with U.S.Weather bureau and U.S.Geological survey.

Study of the probable run-off volumes from small drainage basins is made to improve forecasting flood conditions for larger areas. Schematic diagrams of rainfall-runoff relations indicate the infiltration capacity in form of additional capillary water and ground-water recharge. Unit-basin analysis is illustrated by the example of the Susquehanna river above Towanda,Pa., an area of 7,797 square miles,and the unit hydrograph is derived for the storm of November 4, 1936. A chart shows the relations of precipitation and infiltration for this area and a description is given of its development. It was observed that infiltration rates are proportional to rainfall rates. Curves are also given showing ground-water recharge from infiltration for this area. Many curves accompany the description of other hydrologic factors in this study.

185. Snyder,F.F. Synthetic unit-graphs. Amer.Geophys.Union Trans.(1938) 19,pt.1:447-454,illus.,processed. 330.9 Am3 19th,pt.1,1938

Presentation of method for deriving synthetic unit-graphs applicable to drainage-areas of 10 to 10,000 square miles and the approximate method for determination of the "lag," the principal drainage basin characteristic used for deriving the synthetic unit-graph and the distribution graph. Example given of a unit-graph for the French river basin above Dandridge,Tenn. Owing to the maximum infiltration-capacity being reached (or limits sets by existing infiltration-capacity) in large floods, a greater percentage of the total flood run-off occurs as true surface run-off than subsurface stream

flow which is not the case in normal flow. The unit-graph procedure is satisfactory for most ordinary streams but difficulties arise in very intense storms on areas as large as 3,000 square miles. It is a means of determining the time-distribution of surface-run-off, but does not solve how much run-off will occur under any given set of conditions.

186. Snyder,F.F.,Bernard,M.M.,Sherman,L.K.,Horner,W.W.,and Flynt,F.L. Discussion [of paper 1926,Relation between rainfall and run-off from small urban areas]. Amer.Soc.Civ.Engin.Trans.(1936)101:184-205. 290.9 Am3 101st,1936.

Also Amer.Soc.Engin.Proc.v.62,pt.2,no.8. Oct.1936.

Paper 1926 was presented by W.W.Horner and F.L.Flynt. The foregoing persons contributed to the portion of the discussion relating to infiltration.

The infiltration rates,determined from certain individual storms, were given. According to Mr.Horton,the infiltration capacity of a natural soil is high when the rain begins,decreases rapidly at first, and approaches stability within an interval ranging commonly from 1 to 3 hours. The infiltration rate varies directly as the intensity of precipitation. The development of methods for determining the quantities of run-off,storage capacity,and infiltration were discussed and data from several storms were used for supporting evidence. Many graphs, illustrations,and tables of data are included.

187. Sokolovsky,A.N. The problem of soil structure. Internatl.Soc.Soil Sci.First Comn.,Moscow,U.S.S.R.Trans.(1933)v.A,1,pt.A,1:34-110. 56.9 In81Co. v.A,1,pt.A,1,1933

The work on soil structure problems by many other investigators and several tables of their data are reviewed. The various structure factors are discussed in considerable detail. The action of Ca and Na on colloids to change permeability and the function of humus are considered at great length. A virgin soil is much more dense than one plowed (both measured in a plowed condition) and water does not penetrate into a virgin soil as it does into a plowed soil. Many factors such as the effect of vegetation on the soil structure are taken into consideration. Citations are made to a large number of references.

188. Spencer,J.N.,Kimball,F.,and Kellogg,J.C. The results of run-off and infiltration studies by use of a mechanical rainmaker apparatus on Colorado soil conservation projects. 17 numb.l., illus.,mimeogr. Colorado Springs,Colo.,July 1937. 1.9608 R31

Issued by U.S. Soil Conserv. Serv., Southwest region, Albuquerque, N. Mex.

About 300 tests were made with an artificial rainmaker(which is fully described and illustrated)at several locations in the eastern half of Colorado to determine the hydrologic interrelation between water,soils,and vegetative cover. Tabular and graphical data of several of these tests are given. In summarizing the authors state that the mechanical rainmaker does not simulate rainfall;that land usage is by far the most important factor to consider in arriving at a run-off coefficient;and that the stabilized infiltration method of testing run-off is more accurate than the rainfall pattern tests due principally to lack of precise information on typical rainfall conditions existing in a given area.

189. Sprague,H.B.,and Marrero,J.F. The effect of various sources of organic matter on the properties of soils as determined by physical measurements and plant growth. Soil Sci.32(1):35-47. July 1931. 56.8 So3

Percolation rates of water through three soils,each treated with five types of organic matter, were determined by adding water to a cylinder 4 inches in diameter inserted in each soil. Sufficient water was added to maintain at least a depth of 1/4 inch over the surface and the quantity collected from the drain over a given period furnished the index desired. Pore space was calculated from specially taken samples. The analyses of the materials used are given as well as tables of data on these soils and mixtures showing the available water-holding capacity before and after growth of grass,the pore space of soil after growth of grass compared to the check,and the amount of percolation of water in a 15-minute period. These results and the exceptions of organic matter additions to the soil failing to increase the percentage of pore space or rate of percolation are discussed. The authors conclude that the addition of organic matters of any type largely prevent the formation of cracks,modified the physical properties of the soil and increased plant growth.

190. Stauffer,R.S. Infiltration capacity of some Illinois soils. Amer.Soc.Agron.Jour.30(6):493-500,illus. June 1938. 4 Am34P

Infiltration measurements were made by a method similar to Musgrave's by forcing 8-inch greased cylinders into the soil to the B horizon. These tests were made on grassed areas of 14 Illinois soils ranging from impermeable to highly permeable soils. The grass was removed preceding the test, Soil moisture determinations were made on soil adjacent to the test areas and reported. Tables of data giving the physical characteristics of the soils tested,and the summarized infiltration measurements for each soil are given.

191. Stauffer,R.S.,and Smith,R.S. Variation of soils with respect to the disposition of natural precipitation. Jour.Amer.Soc.Agron.29(11): 917-923. Nov.1937. 4 Am34P

Methods are described and results summarized from a research project set up at Ill.Agr.Expt.Sta.,in which the erosion-type lysimeter (similar to Musgrave's) was used to study the infiltration capacity of several typical soils of the state of Illinois. Data covering a period of $1\frac{1}{2}$ years are given for run-off and percolate for eight soil types. Photographs of the lysimeters are included.

192. Stephenson,R.E. Root penetration in relation to soil aeration. Oreg.State Hort.Soc.Proc.(1935)27:19-33. 81 Or32 27th,1935

Report of the 50th annual meeting.

A table of data (calculated from Slicter's formula) is given showing rates of water penetration for soil grain sizes of 1 micron (colloidal clay) to be 1" in 41 days,10 microns (fine silt) to be 1" in 40 days,100 microns (fine sand) to be 1" in 6 min.,and 1000 microns (coarse sand) to be 1 ft. in 43 seconds. The grains are assumed to be uniform size and sphorical with most open packing. The formula used was checked on field soils by King of Wisconsin. For the rate above there are assumed a constant head (supply of free water),a downward movement,and a free outlet.

193. Taylor,C.A. Water penetration in hardpan citrus soils. Agr.Engin. 15(6):202-203,illus. June 1934. 58.8 Ag83

Furrows are laid out in citrus orchards for irrigation between rows of trees. The rate of absorption of water in irrigation furrows in 30 year old navel orange grove on Yolo gravelly loam, Corona,Calif.,is given in tabular form for different rows. Variations in rate are discussed and also the formation of hardpan. The procedure under investigation for lessening the amount of hardpan formed is given in detail.

194. Thompson,W.R. Moisture and farming in South Africa. 260pp.,illus. South Africa,Central news agency,ltd.,1936. 340 T37

Rainfall,soil erosion and run-off in South Africa,pp.126-159.

The humus content of the soil exerts a marked influence on the absorption of water and concomitant run-off. It adds porosity to the soil. Humus colloids bind together the coarser soil particles. The effect of vegetation on increasing penetration of the water into the soil is fully discussed. No data on infiltration rates are given.

195. Troxell,H.C.,Rowe,W.P.,and others. Discussion [of paper 1756, Water supply from rainfall on valley floors.] Amer.Soc.Civ. Engin.Trans.(1930)94:1269-1311,illus. 290.9 Am3 v.94,1930
Also in Amer.Soc.Civ.Engin.Proc.55(5):1139-1165,illus. May 1929
Paper 1756,Water supply from rainfall on valley floors,was presented by A.L.Sonderegger.
According to Troxell,storm run-off depends not on seasonal rainfall,or even storm periods,but on the instantaneous rate of the rainfall and the condition of the canyon storage. Every acre of the canyon has a certain uniform rate by which it absorbs the rainfall if storage is available. Data are given on rates of absorption.
According to Rowe's discussion on determination of rainfall penetration from test wells in Pauba valley of Temecula river, Riverside county,Calif.,the infiltration observations from test plots did not result from rainfall on the surface but from water concentrating in gullies.

196. U.S.Dept.of agriculture. Relation of forestry to control of floods in Mississippi valley. 740pp.,illus. Washington,U.S.Govt. print.off.,1929. 148 9018
House Doc.573,70th Congress,2d session.
Forest and flood relationships in the Mississippi river watershed,pp.53-84,by E.N.Munns.
Investigations at the California forest experiment station indicate the effect of forest litter on infiltration rates. Litter is the most important element of the forest on distribution of rainfall into superficial run-off and seepage. The function of the forest litter to absorb water is insignificant in comparison with its function to maintain the percolation capacity of the soils. It keeps the water reaching the soil through seepage channels clear,even during the most intense beating storms,whereas the superficial run-off on areas devoid of litter soon becomes muddy. The suspended particles are filtered out at the surface as the muddy water percolates to the soil.
The surface soil of a natural forest is usually covered with leaves and twigs protecting it from the raindrops striking it direct and destroying the granules as they tend to do in cultivated fields. Also the litter prevents the beating drops of rain from so rearranging the particles that they clog up the pores in the soil and cement the channel openings. In other words, with a litter mulch the rain does not distrub the surface soil by its beating action,but the water is kept clean at all times as the litter and raw humus strain out any pore-clogging material,and the water reaches the soil by percolation,rather than directly,and in such a fashion that the water can be absorbed at a much greater rate than from a bare soil.

197. U.S.Engineers office. Hydrology in the Los Angeles county drainage area. 74 numb.l.,44 exhibits,processed. Los Angeles,U.S. Engineers off.,Mar.1939.

At head of title: Los Angeles and San Gabriel rivers and tributaries. California survey for flood control.

Of interest is: Run-off coefficients on leaf 28,and exhibits 25 to 27 inclusive. These run-off coefficient curves are based on data from test plots of the Los Angeles county flood control district and modified by the rainfall-runoff relations of the 1938 flood. The exhibits show curves applicable to the valley floor, agricultural,suburban,and industrial areas.

198. U.S.Forest experiment station,Appalachian,Asheville,N.C. Manual for the compilation of hydrological data from small drainage areas. 53 numb.l.,illus.,mimeogr. Asheville,June 1938. 1.9 F7623M

"This manual has been prepared by L.K.Hill...and K.A.MacKichen..."

Determination of mean infiltration capacity,pp.43-53.

The infiltration capacity per hour is determined for a 145.5 acres of forested area. These rates are determined from the hydrological data consisting of 27 entries for each of 23 individual storms occurring from May 3 to October 23,1936 at the Coweeta experimental area. Several graphs including hydrographs are given in the article.

199. Warington,Robert. Lectures on some of the physical properties of soil. 231pp.,illus. Oxford,Eng.,Clarendon press,1900. 56 W23L

Relations of soil to water,pp.51-91.

The studies of the rates of percolation of water through soils by other investigators are reviewed as well as the percolation of rainfall from the drain-gages at Rothamsted. Effects of temperature upon the amount of water retained by the soil and upon the rate of percolation are considered. The water from rain may pass through the soil by channels formed by worms,roots of plants,rodents,etc., before the soil is saturated. Summer drainage of such soils is often chiefly of this character. Percolation is greatest where the retention of water is least; the characters of the soil which produce little retention are favorable to a large percolation, and vice versa.

200. Weaver,J.E.,and Noll,W. Measurement of run-off and soil erosion by a single investigator. Ecology 16(1):1-12,illus. Jan.1935. 410 Ec7

An apparatus called an interceptometer is described in detail providing for measurement of water accumulation and run-off. A complete study of the water relations should include measurement

of run-off as well as water accumulation or run-in from surrounding areas. Data from tests are given with the time of application of water as well as period of run-off cessation permitting the determination of the infiltration rate. The experiments were carried out on plots 2' x 33.3' under various types of vegetative cover. The results are discussed.

201. Welitschkowsky,D.V. Experimentelle über die permeabilität des bodens für wasser. Arch.f.Hyg.2:499-512,illus. 1884. 449.8 Ar2

In German. Title: Experiments concerning the permeability of the soil for water.

In a series of experiments on percolation of water through soils of various characteristics, temperature of the water was shown to increase the rate with each increase in temperature. Experiments were made at 5° C. and at 10° intervals from 10° C. to 100° C. with soil depth of 25,50,75, and 100 centimeters. The measurements of various characteristics of the soil used in each experiment are given. The formula derived for calculation of the quantity of percolate in unit time is

$$Q = k.\frac{h.D^2r^2}{L} \quad (1 + 0.0136t + 0.000704t^2)$$ where

k is a constant depending on the quality of the soil, h is the height of the water column above the soil surface, L is the depth of the soil layer, D is the diameter of the tube containing the soil, r is the radius of the grain size and t is the temperature in degrees centigrade.

202. Whelan,L.A. The effects of lime on the soil. Scot.Jour.Agr.20(3): 258-263. July 1937. 10 Sco82So

Tests were made determining the rates of infiltration of water into an unlimed soil, into the same soil limed at rate of 1 ton per acre, and into the same soil limed at rate of 2 tons per acre. Data are given showing the increased rate obtained by liming. The tests were made 12 months after liming and again after a 3-year period.

203. Wollny,E. Untersuchungen über die permeabilität des bodens für wasser. Forsch.auf dem Geb.Agr.-Phy.14:1-28,illus. 1891. 395 F77

In German. Title: Investigations concerning the permeability of the soil to water.

Descriptions of the apparatus and method are given for determining the quantity of water passing through sand, humus, calcareous sand, loam, kaolin, or mixtures of some of these materials during a 10-hour period. The rates are given for water pressure heads ranging from 10 to 100 cm. for different depths of material tested. For some of the materials tested, the ranges of particle size are given. The author discusses the application of results of his tests to field conditions.

204. Woodruff,C.M.,Smith,D.D.,and Whitt,D.M. Results of studies involving the application of rainfall at uniform rates to control plot conditions. 91pp.,illus.,mimeogr. Washington,D.C.,June 1938.
1.96 R31Res

Issued by U.S.soil and water conservation experiment station, Bethany, Mo.

Descriptions of the machine,nozzles,and plots used in rainfall-simulator tests at the Soil conservation experiment station during the years 1936 and 1937 are given. The sprinkler-experiments,continued to and beyond the time of concentration,give hydrographs from which infiltration-capacities can be read directly. The method is direct,simple,and accurate. The experiments were made at Bethany,Missouri,with bluegrass sod and cultivated surfaces. The applications of results to the design of future studies are included.

205. Zoch,R.T. The mathematical synthesis of the flood-hydrograph. Amer.Geophys.Union Trans.(1939)20,pt.2:207-218,illus.
330.9 Am3 20th,pt.2,1939

The definitions of terms relating to infiltration are given. The relation of infiltration rates under the conception of steady states to other factors is presented. A major portion of this article is devoted to definitions and to the breakdown of the hydrograph.

206. Zwerman,P.J. The relation of sheet erosion to the structure of Duffield silt loam. Soil Sci.Soc.Amer.Proc.(1938)3:304-311, illus. 56.9 So3 v.3,1938

Cropping history of the experimental areas was obtained and infiltration rates were determined by Musgrave's method. Many graphs and other illustrations are presented showing physical properties of the soil profiles of each area,which had been selected partially by the degree of erosion it had undergone, by the mean infiltration rate for each erosion-area,and by other factors. The variation in rates of infiltration is explained on the basis of effective soil porosity which is governed by the number and size of soil aggregates and their relation to confined air and non-capillary soil porosity.

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SOIL CONSERVATION SERVICE BIBLIOGRAPHIES

No. 1. Wind erosion and sand dune control;a selected list of references. June 1940.

No. 2. Personnel administration and personnel training. A selected list of references. August 1940.